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NEW YORK, MAY, 1893.

IN our April issue there was a typographical error in the solution of the "Locomotive Problem," by C. H. Lindenberger. The diameter of the drivers should have been 7 ft. instead of 8 ft., as given.

## EDITORIAL NOTES.

THE latest report regarding the annual coal production of the world credits the United States with an output of 140,000,000 gross tons, with Germany second with 90,000,000 gross tons, and Great Britain third with 85,000,000 gross tons. At the same time there has been a slight advance in the average price.

IT is said that American pig irons are gradually displacing the English and Scotch products in Central and Western Canada. At Montreal, where the foreign irons are landed, they have the advantage in price, but when the cost of land transportation is added, it becomes impossible to sell it in competition with American iron made in Ohio and Pennsylvania.

THE report is in circulation that Professor Elisha Gray's new telautograph has been tested by experts in New York and Chicago, and that they are full of enthusiasm over its possibilities. The action of the instrument is the reproduction at the receiving end of the wire of any figure or writing that is drawn on a piece of paper with a pen at the sending end.

THE daily papers are continuing their hue and cry regarding the refusal of the railroads to give greater reduction of fares to Chicago, on the plea that the present rates will deprive hosts of people of the pleasure of the trip, and yet the people of Chicago, by the extortionate rates which they propose to charge for rooms and hotel accommodations, are doing their very best to deter the public from visiting the city.

A FEW years ago there was considerable discussion relative to the possibility of an 18-hour train between New York and Chicago. A rumor is abroad that this is about to be approached by a 19-hour express over the New York Central & Hudson River Railroad. The long success of the Empire State Express in making schedule time between New York and Buffalo has led to the decision to maintain the same speed with a similar train on to Chicago.

A NEW department is being added at the Superior hard ore mines. For some time the soft high-grade ores have been crowding the hard ores out of the market, because the former came to the furnaces ready for smelting, while the latter had to be crushed. Lately crushers have been added to the plant at the mines, and the result has been that while there is some additional expense to the mine owners, the increase in their orders more than compensates them for the extra labor involved.

THE "Good Roads" movement seems to have gained a firm footing in many parts of the country, and the probabilities are that before long the work of improvement will be begun. Governor Flower, of New York, has already signed a bill which authorizes the warden of Clinton Prison to employ the convicts in road making within a radius of twenty miles of the prison, and if the attempt is successful the same authority will probably be extended to the wardens of the other prisons of the State.

OUR pages are a cotemporary chronicle of the advancement that is being made in the shipping interests of the great lakes. There is hardly a month but that some new vessel is projected or launched, until now they have come to assume the dimensions of the best of the Atlantic liners of a few years back. This advancement was brought out very prominently at a dinner given in Duluth, where Mr. James J. Hill, President of the Great Northern Railway, stated that his Company is building two steamers capable of carrying 350 first-class passengers, and of making the trip from Buffalo to Duluth, a distance of 1,000 miles, in 50 hours, adding, in conclusion, his belief that this would result in the establishment of a daily line.

## BOILER TUBES.

FOR some months past, or perhaps it may be said for several years, English engineering journals have contained many articles, papers, and much correspondence on the subject of boiler tubes, the chief burden of which is the difficulty of keeping marine boiler tubes from leaking, especially when forced draft is used. One effect of the trouble, a correspondent intimates, is that many of the engineer officers in the British Navy are getting *bald*. It is not surprising, therefore, that the subject of boiler tubes is attracting much attention at present.

It has never been satisfactorily explained why this difficulty is so much more serious in marine boilers than it is in locomotives, or, in other words, why locomotive tubes can be kept tight and those in marine boilers cannot. *Engineering* of February 24 contained a long editorial article, in which the whole subject was summed up, or, rather, the evidence re-

lating to it. The difficulty is attributed to a variety of causes, and many cures have been proposed. One correspondent points out that the difference in temperature between the inner and outer surfaces of the tube-plate causes the latter to become convex toward the fire, and he advocates the use of thin tube-plates. Other correspondents predict that thin tube-plates will not stand long service, whereas Mr. Yarrow recommends thin tube-plates, and says there is no difficulty from their want of strength, and that they may be sufficiently stayed by the tubes alone, even when these become leaky.

There has been a good deal of conjecture with reference to the question whether the tube-holes are contracted or expanded by heat in ordinary service. One correspondent asserts that the *cause* of tube leakage is the transverse compression of the tube by the "nip" due to the expansion of the overheated tube in the plate—that is, the expansive action of the heat produces a permanent set in that portion of the tube inside of the hole in the plate, and when the tube is cooled and contracted, it becomes smaller than the hole, and consequently leaky. The same correspondent says: "The cause of the delay in improvement has, in my opinion, certainly been due to the fact that nearly all effort has been in the direction of improving the joint and in reducing mechanically the strain on the tube-plate, while it should have been aimed at an improvement in the circulation past the tube-plate and fire-box stays." He proposes as a remedy for the evil a system of circulating plates and a "helical fan," or a sort of screw working in a tube in the boiler, and driven by a light engine outside, so as to force the water past the tube-plate and fire-box sides.

On the other hand, Mr. A. J. Durston, Engineer-in-Chief of the British Navy, does not look for salvation in thin tube-plates, or, as *Engineering* says: "His contention is that all trouble comes from overheating; that, be tube-plates thick or thin, tube ends will leak if the evaporation be rapid, unless circulation of water against the tube-plate be unobstructed. He has recently read a paper before the Institution of Naval Architects on Some Experiments on the Transmission of Heat Through Tube-plates, in which are reported a variety of experiments and investigations bearing upon this subject, and to which reference will be made later on. Other disputants also attribute the difficulty to a want of circulation.

The arrangement of tubes in vertical and in horizontal rows has also been discussed, and some correspondents claim to have realized much advantage from arranging them in horizontal instead of vertical rows. It should, perhaps, be explained that to lay off tubes in horizontal rows a radius equal to the distance between the centers of adjacent tubes is taken. With this radius describe a circle. Its center will be the center of one tube. Then draw a horizontal line through the center of the circle. The intersections with the circumference will be the centers of other tubes, which will be in a horizontal row. With the radius of the circle and from the points of intersection subdivide the circumference into equal parts. The points of subdivision will be centers of more tubes, which will be in horizontal rows. To lay them off in vertical rows, proceed as explained, but draw a vertical instead of a horizontal line through the center of the circle.

Whether the favorable results which were claimed were due to the horizontal arrangement is, however, disputed.

Another plan for promoting circulation which has been proposed is to direct the feed water across the surface of the tube-plate, thereby inducing a current; but the good effects of this are also disputed.

A variety of circulating plates in boilers, arranged in different ways, but having the common object of dividing the ascending from the descending currents, has been suggested.

Various methods of protecting the tube ends by ferrules have been tried. These are made of different materials, malleable cast iron being perhaps the most satisfactory. A composition of plumbago, ganister, and fire-clay, and plastering the tube-plate or protecting it with fire-tiles have been experimented with; all of these are intended to act on the principle of reducing the transmission of heat through the tube-plate and tube ends.

There seems to be a very general unanimity of opinion that greater care and better workmanship is required in fastening tubes. Mr. Yarrow showed the evil effects of driving a tapered mandrel into a tube fitted into a parallel hole. The editor of *Engineering* says, with reference to this point—and we think all good mechanics will agree with him—that "a point of considerable importance is that the tubes should be free from rust or scale at the points where they come in contact with the tube-plates. In the case of iron or steel tubes these portions of the external surfaces should be thoroughly cleaned, either by grinding or filing, prior to the tubes being inserted, and that, moreover, every care should be taken to prevent the parts so cleaned from becoming rusty prior to the tubes being actually fixed."

In *Engineering's* article there is no reference made to the use of copper ferrules between the tube ends and tube-plate. It is, we believe, the general experience of nearly all locomotive superintendents in this country that it is difficult to keep iron tubes tight without using such ferrules. There is nothing said, either, about the fact that the tubes must expand more than the shell of the boiler, owing to the heat coming in direct contact with them. This surely must have a very considerable effect on the joints of the tubes in the tube-plate.

The discussion calls to mind that old historical one of whether a pail of water would weigh more with a fish in it than it would without. As a matter of fact, we are very ignorant of what occurs in the inside of a boiler; and if it were possible to get a good view of what takes place in, say, a locomotive boiler when a rapid rate of combustion is going on in the fire-box, it would probably increase our knowledge very materially. It does not seem impossible to illuminate the whole interior of such a boiler with electric lights, so that every part would be visible, and could be photographed through openings properly protected with glass. To use a feminine expression, it makes one "ache with curiosity" to get a view of that kind.

The paper on The Transmission of Heat Through Tube-plates, referred to above, which we regret we have not room enough to reprint in our pages, is to a great extent a report of investigations intended to throw light on this imperfectly understood subject. We can give only the briefest abstract of the results of these investigations.

It was found, first, that the temperature of the hot side of a clean plate ½ in. thick through which heat is passing to boiling water was about 240° F. Next, it was shown that with a coating of grease, obtained from the inside of a boiler, on the water side of the plate the temperature on the other side was about 330° F. Both experiments were made over a Bunsen burner.

To ascertain the temperature at the center of its thickness

of a plate ⅝ in. thick, resembling a boiler tube-plate exposed to a forced blast fire, holes were drilled in the center of the thickness of the plate in a direction radial to the tube hole. These holes were filled with square pieces of fusible alloys. The temperature of the fire was about 2,000°, and the alloys whose fusing temperature was 290° were melted, but those which would melt at 336° were not.

To determine the temperature of the tube-plate at which injurious overheating—*i.e.*, such as to cause leaky tubes—takes place, a boiler with brass, steel and iron tubes was constructed, and was then heated to a temperature of 630°, at which lead melted. On being tested afterward to a pressure of 200 lbs. to the square inch, the tubes were found to be practically tight. On heating it to a temperature at which zinc melted—750°—two of the brass tubes split, and it was found necessary to roll two other brass tubes. On being tested again with 200 lbs. pressure, a few of the brass and steel tubes leaked slightly, the iron tubes being without a weep. After being heated so that the tube-plate showed a red heat—about 1,400°—the boiler, on being tested with water, all the tubes leaked so badly that no pressure could be maintained. It was, therefore, inferred that a tube-plate, to be overheated sufficiently to make tube joints leak to an appreciable extent, must be raised at least to the temperature of melting zinc—viz., 750°.

Experiments were made which showed that the loss of efficiency of the heating surface of tubes in a boiler due to a thin coating of grease deposit was from 8 to 15 per cent., the mean of many experiments giving 11 per cent.

The temperature of plates when boiling water under various conditions at a higher temperature than 212° was found to be as shown in the following table :

| | Temperature of Hot Side of Plate. | Temperature of Water. | Difference. |
|---|---|---|---|
| | Fah deg. | Fah. deg. | Fah. deg. |
| Over Bunsen burner | 430 | 363 | 67 |
| Over blast forge (full blast) | 430 | 344.5 | 85.5 |
| Over forge fire—grease deposit $\frac{1}{16}$ of an in. thick | 510 | 359 | 151 |
| Do., but using grease of drier or earthier nature | 550 | 351 | 199 |
| Do., and spreading the grease up the sides of the vessel as well | 617 | 80 | 537 |

Experiments on the behavior of tubes of various materials showed that brass and copper tubes leaked even when the plate was below the temperature of melting lead—617°—showing that these materials did not stand as well as iron and steel.

It was not found that at the higher pressures there was any marked addition to the excess of temperature of the hot side of a plate over that of the boiling water.

Experiments were made to determine the temperature of the center of the thickness of a tube-plate with an experimental boiler working with closed ash-pits and moderate air pressure. To do this, holes were drilled in the middle of the plate in a radial direction from the inside of the tube hole, and various alloys with different melting temperatures were inserted. With a temperature of 3,100° in the combustion chamber, the temperature in the middle of the plate rose to 530°, but was less than 540°.

Further experiments were made to ascertain the temperature of the fire side and middle of thickness of tube-plate in experimental boiler with forced draft and closed stoke holes. With temperatures in the combustion chamber varying from 2,500° to 3,200°, the temperature at face of plate was 1,060°, and at middle of plate was between 680° and 750°.

It was shown, by another series of trials to determine the behavior of Lowmoor iron *versus* steel tubes as regards leakage in the experimental boiler, that the former are at least not superior to steel ones ; and as the latter, it is said, will stand more rolling than the ordinary iron tube of commerce, it seems to justify a preference for steel tubes.

Of these trials it is said that the "first trial was of five hours' duration with 3-in. air pressure. No leakage of tubes occurred at this trial. Second trial of five hours' duration with 3-in. air pressure for first two hours and 3½ in. for next three hours. At the conclusion of this trial the fan was kept going for some time after drawing the fire, *but no leakage of tubes occurred.* Attention is called to this fact, as great stress is frequently laid on the action of cold currents of air in producing leaky tubes."

After this trial mineral oil was introduced into the boiler, and leakage then soon commenced. The experimental boiler, although subjected to the high temperature of about 3,000° in the combustion chamber and 1,600° in the smoke-box, and further subjected to hard treatment by admission of cold air through the tubes after drawing the fire at the conclusion of the second trial, did not leak till grease was used in it.

To determine the temperature at various parts of the tubes of an ordinary marine boiler, a series of experiments was made. The boiler had two furnaces and 166 tubes 2¾ in. external diameter and 6 ft. 8 in. long, the consumption of coal being about 17 lbs. per square foot of grate. The following are the mean results of eight sets of records :

| | Deg. Fah. |
|---|---|
| Temperature in combustion chamber | 1,644 |
| " just inside tube | 1,550 |
| " in tube 1 in. from combustion chamber | 1,466 |
| " " 2 in. " " | 1,426 |
| " " 3 in. " " | 1,405 |
| " " 4 in. " " | 1,412 |
| " " 5 in. " " | 1,398 |
| " " 6 in. " " | 1,406 |
| " " 7 in. " " | 1,400 |
| " " 8 in. " " | 1,410 |
| " " 1 ft. 2 in. " " | 1,368 |
| " " 1 ft. 8 in. " " | 1,295 |
| " " 2 ft. 8 in. " " | 1,198 |
| " " 3 ft. 8 in. " " | 1,106 |
| " " 4 ft. 8 in. " " | 1,015 |
| " " 5 ft. 8 in. " " | 926 |
| " " 6 ft. 8 in. " " | 887 |
| " in smoke-box | 782 |

In commenting on these tests, the author of the paper says that they show "that even beyond 6 ft. in length there is an appreciable transfer of heat. If this is the case with a boiler burning only 17 lbs. of coal per square foot of grate per hour, it would be interesting to know how much heat is transferred to the water through the front ends of locomotive tubes when from 100 to 200 lbs. of coal are burned in the same time.

The experiments summarized above concluded those made on a small scale. Others on a larger scale were made on shipboard, with the object of avoiding leakage of boiler tubes. It is remarked in the paper that considerable trouble has been experienced with leakage of tubes in the double-ended common combustion chamber boilers and those of the locomotive type. Various expedients were tried in some of the boilers to overcome the leakage. These were as follows : "Rolling tubes with a shoulder inside the tube-plate ; beading tubes over the tube-plate ; rolling the tubes parallel ; fitting ordinary ferrules in tubes ; shortening the grates, involving an increase in the air pressure ; replacing the stays from the top of the combustion chamber to the shell of the boiler by dog stays having no connection with

the top of the boiler. No definitely beneficial results," it is said, "have attended any of these measures. The modification in those boilers that gave the greatest benefit was

Fig. 3. Fig. 2.

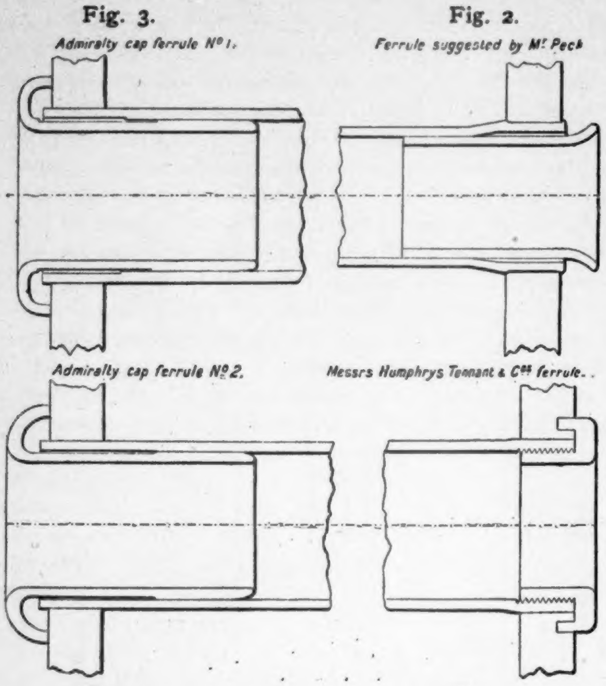



Fig. 4. Fig. 1.

that of removing two vertical rows of tubes over the center of each furnace." It is said, further :

"Concurrently with the efforts that were being made to overcome the leaky tube troubles by improving the circulation, experimental trials were being conducted in the locomotive boilers of the torpedo gunboat class (1) by plastering the tube-plate with a non-conducting composition, thus protecting it on the fire side ; and (2) by ferruling the tubes with fire-clay cap ferrules, the caps of which afforded protection to the tube ends and the larger part of the tube-plate. The object of these experiments was not to demonstrate the effectiveness of the materials used, but to show whether the leakages of boiler tubes were not due to the overheating of the tube-plate and ends. This was established, for as long as, in the first case, the cement adhered, and in the second case the ferrules lasted, leakages did not occur. They were, however, both liable to rapid destruction, and could not be relied on as a permanent protection."

The report goes on to say :

"Among the first of the practical suggestions made for ferruling the tube ends was that patented by Messrs. Humphrys, Tennant & Company, and illustrated by fig. 1. It will be seen that this ferrule is screwed into the tube at the fire-box end, and that the cap fits into an annular recess cut in the tube-plate. The principle of this ferrule is that when a contraction in diameter takes place, due to variations of temperature, the outer part of the ferrule tends to tighten upon the concentric portion of the tube-plate. Further, as the ferrule is screwed into the tube, it has the advantage of the holding power afforded by the rolling of the tube into the cooler smoke-box tube-plate. It will also be seen that from its construction it provides a large amount of jointing surface, and an intricate passage to prevent the escape of water. On the other hand, it has the disadvantage that ferrules cannot be withdrawn for cleaning and repairs, but must be cut out, and it is somewhat costly in fitting."

These ferrules were fitted into the tubes of the boilers of the *Medea*, and during her trial gave good results.

Fig. 2 shows a ferrule proposed by Mr. Peck, of Messrs. Yarrows' firm. In this the tube ferrule, or protector, does not touch the tube where it is fixed in the tube-plate, but is in contact with the tube only at a part where all its heat may be readily absorbed.

Fig. 3 was proposed by Mr. Oram, engineer inspector, and in addition to the features embodied in Mr. Peck's ferrule it has a cap to protect the tube end and the greater part of the fire-box tube-plate from direct contact with the products of combustion. Experience resulted in the shape of ferrule shown in fig. 4. To make a practical test, these ferrules were fitted in the *Barracouta's* boilers. The port boiler was fitted with wrought-steel ferrules, and the starboard boiler partly with the same, and partly with malleable cast-iron ones. Very complete trials of the boilers were then made with satisfactory results. It was noticed that the scaling of the malleable cast-iron ferrules appeared to be much less than that of the wrought steel.

After this test of the ferrules they were fitted into the boilers of the *Thunderer* and thoroughly tested, also with satisfactory results.

This interesting paper ends by saying :

"These cap ferrules have been fitted to several other ships having various types of boilers with satisfactory results, and requests for them are being made by ships of the fleet, with the view of protecting the tube-plates and ends from overheating. Whether by want of circulation, excessive temperature in the combustion chamber, or from the presence of grease or solid matter, it is submitted these cap ferrules have fully answered their intended purpose."

From the testimony which has been quoted it might be inferred that the leakage of marine boilers is due chiefly to the overheating of the tube-plates, which is a consequence of either defective circulation or the presence of grease in the boiler. If this is the true reason, it is a curious fact that there is so much less trouble from leaky tubes in locomotive boilers, where the fire-box temperature must be much higher and where the circulation of water can hardly be as good as in marine boilers. Furthermore, the author of the paper from which we have quoted so liberally expresses the opinion that the method of fastening tubes in the plate seems to have little influence on their tightness. The experience of locomotive superintendents and master mechanics in this country, we think, would not confirm this deduction. The great preponderance of practice here with iron and steel locomotive tubes is that it is of the utmost importance that they should have copper ferrules between the tube end and tube-plate at the fire-box end, and should be beaded inside the fire-box tube-plate and turned over on the outside—in other words, that the method of fastening is of the utmost importance.

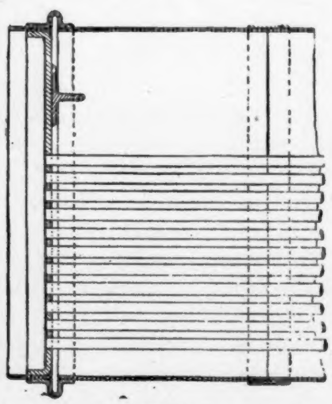


Fig. 5.

It is curious, too, that there is no reference in the paper to the effect of the difference in expansion of the tubes and

the shell of the boiler. It is a very common impression that long locomotive tubes are much more difficult to keep tight than short ones. The breakage of stay-bolts is often attributed to the expansive action of the tubes. A recent number of the *Railway Engineer* contains a description of a method of construction of locomotive boilers intended to overcome this difficulty. This is shown in figs. 5 and 6. It has been patented by Mr. Martin Atock, M.Inst.C.E.I., Locomotive Superintendent of the Midland Great Western Railway of Ireland, to allow a locomotive boiler to "breathe" freely.

In describing it the *Railway Engineer* says :

"The difference between the expansion of the brass or copper tubes and the iron and steel shell of a locomotive boiler is well known, and Mr. Atock drew attention to the evils which are chargeable to this cause in a paper which he read before the Inst. C. E. of Ireland in April, 1882. Soon afterward Mr. Atock had a boiler fitted up as an experiment with a single bowling-iron expansion ring, as shown at fig. 5, and it worked most successfully for seven years, when the constant working or "breathing" caused grooving to take place at *A*, and a new ring had to be put in.

"In order to minimize the grooving Mr. Atock put in three corrugations, as shown at fig. 6, and these give every indication of lasting the life of the boiler. The flexible tube-plate or corrugated front end ring has the advantage of throwing a less strain on the tubes, as in the latter case they have only the tube-plate to move forward, whereas in the former they have the entire weight of the boiler to thrust backward.

"There are now 27 engines running on the Midland Great Western Railway having their boilers fitted as shown at fig. 6. The first of these engines commenced running in November, 1889, and has accomplished 118,000 train miles, and has given every satisfaction up to the present time. An invention of this kind of course requires a period of years to thoroughly test it, but there is every indication that it will result in a saving of both tubes and tube-plates, to say nothing of the inconvenience of the delays resulting from tube failures and leakages. The corrugations may be either wholly inside the shell or outside, and in the former case the ordinary construction of the shell is not interfered with at all.

"Some idea of the strains which are thrown upon locomotive boilers by the variations of the temperature may be gathered from some careful experiments made by Mr. Atock. In a boiler 10 ft. long between the tube-plates the brass tubes lengthen $\frac{1}{8}$ in. more than the shell of the boiler does when raised in temperature from 60° F. to 212° F., and this movement takes place every time steam is got up or let down. When steam is up to 150 lbs. per square inch, but the engine not at work, the tubes lengthen $\frac{3}{8}$ in. bare and an additional $\frac{1}{8}$ in. full when the engine is working hard, thus making a total of $\frac{1}{2}$ in. Under the same conditions the boiler shell expands only $\frac{1}{4}$ in. bare, so that there is a movement of $\frac{1}{4}$ in., which must take place, and is, with the flush-topped boilers quite unprovided for, and results in the distortion of tube-plates and grooving near the flange of the front tube-plate, breaking off of the ends of tubes near the tube-plates, and the tubes give trouble by working themselves loose and consequently leaking."

It is of course true that the difference in the expansion of brass or copper tubes and the shell of the boiler is greater than that of iron or steel tubes, but owing to the fact that the products of combustion come in contact with the tubes before the water is even warmed, and never comes in contact with the boiler shell, it must be obvious that the expansion of the tubes must be considerably greater than that of the boiler shell.

"Mr. Atock does not use longitudinal or gusset stays, but stiffens the flat portions of the end plates with girders, as shown.

"Mr. Atock's experiment fully bears out Mr. Yarrow's well-known researches with torpedo-boat boilers of the locomotive type. The invariable deductions from Mr. Yarrow's investigations were that the boilers worked under a forced draft required much more freedom to expand than was ever allowed, at least in the Navy."

The first requisite for keeping tubes tight would seem to be to protect them from undue strain from longitudinal expansion.

The second, good workmanship in fastening them in the tube-plate. If any one should try to make a steam-tight joint in, say, a steam-chest cover, and should not finish the surfaces true and smooth, any good mechanic would jeer at him, and yet it is the common practice to fasten tubes in tube-plates with the scale on the ends of the tubes, or if it is removed, it is done by hand, and they are merely roughly filed. That it is impossible to do a good job with such work is not surprising.

The third, protection to the ends of the tubes from overheating by keeping the boiler clean, promoting circulation, and protecting the ends with ferrules such as have been found efficacious in the British Navy.

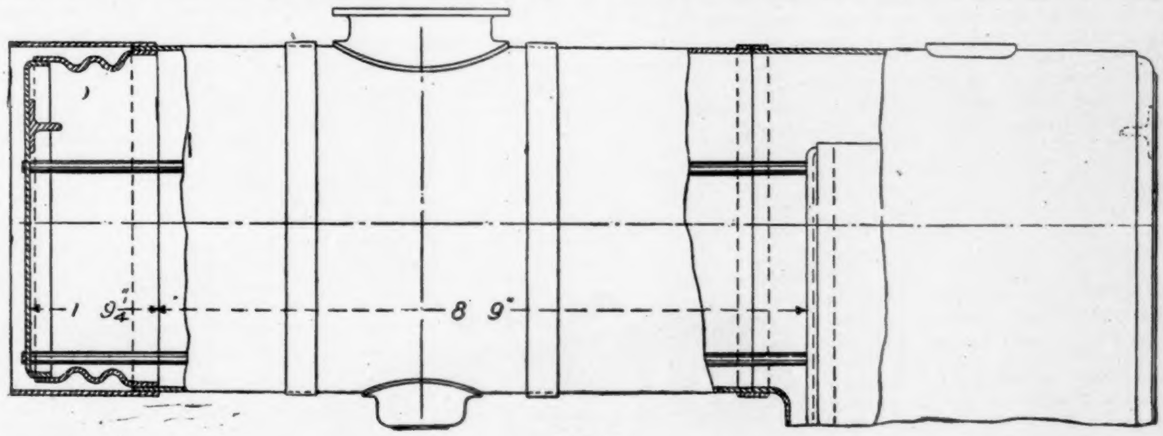



Fig. 6.
ATOCK'S PATENT ELASTIC BOILER BARREL.

## BOOKS RECEIVED.

*The Practical Engineer.* Pocket-book and Diary, 1893. Edited by W. H. Fowler. Technical Publishing Company, Manchester, England.

*The Measurement of Electric Currents.* By James Swinburne, M. Inst. E. E., and C. H. Wordingham, Assoc. M. Inst. E. E. Edited by T. Commenford Martin. Van Nostrand's Science Series, New York.

*Infantry Drill Regulations, United States Army.* Army and Navy Journal, New York.

*Manual of Guard Duty, United States Army.* Army and Navy Journal, New York.

*Switch Layouts and Curve Easements.* By Augustus Torrey. The Railroad Gazette, New York.

*Electrical Measurements and other Advanced Primers of Electricity.* By Edwin J. Houston, A.M. The W. J. Johnston Company, Limited, New York.

*Triangular Surveys from Single Stations.* By Augustus Knudsen, C.E. Brunt & Company, San Francisco, Cal.

*Sewage Treatment and Sludge Disposal.* By W. Santo Crimp. R. J. Bush, London.

*Rules and Regulations Governing Freight Traffic.* By Alfred L. Frazer. New York (Press of Gelhaar, Fleming & Fuller, Rochester, N. Y.).

*Manual of Irrigation Engineering.* By Herbert M. Wilson, C.E. John Wiley & Sons, New York.

*Transactions of the American Institute of Electrical Engineers: Volume IX.* Published by the Institute, New York.

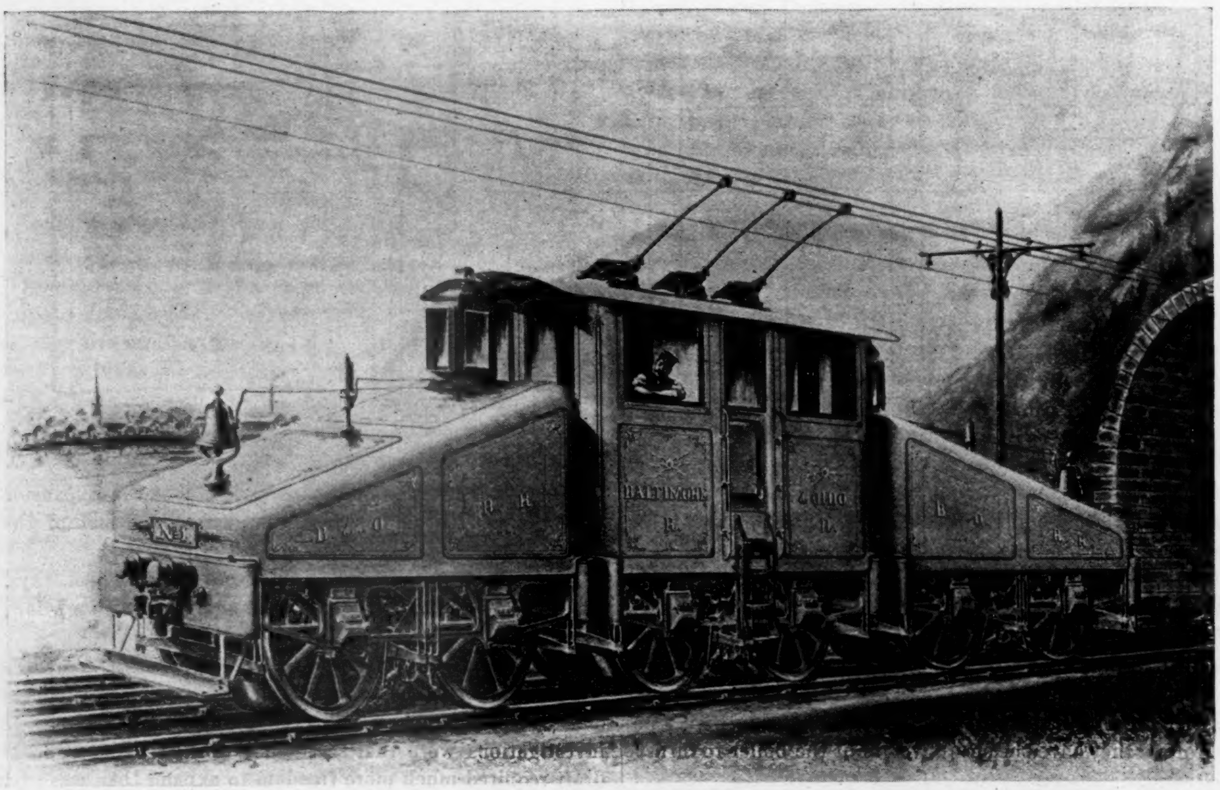
*American Railroads as Investments.* A Handbook for Investors in American Railroad Securities. By S. F. Van Oss. G. P. Putnam's Sons, New York.

*Municipal Improvements.* A Manual of the Methods, Utility, and Cost of Public Improvements for the Municipal Officers. By W. F. Goodhue, C. E. John Wiley & Sons, New York.

*Professional Papers of the Corps of Royal Engineers.* Edited by Captain W. A. Gale, R.E. Royal Engineers Institute. Occasional Papers. Chatham, England.

## ELECTRIC LOCOMOTIVE.

WE give a perspective view of an electric locomotive which is being built for the Baltimore & Ohio Railroad Company, to be used in the Baltimore tunnel. The engine is to weigh 90 tons. As the drawing comes to us just as we go to press we are unable to give any further details of its construction in this issue.



90-TON ELECTRIC LOCOMOTIVE, BALTIMORE & OHIO RAILROAD.

## THE "JOHN BULL."

THE Pennsylvania Railroad Company issued invitations recently which read as follows:

"The original *John Bull* locomotive and train of cars will run from New York to Chicago, over the Pennsylvania Railroad, April 17-22, 1893. Mr. ——, you are respectfully invited to accompany the party from —— to ——.

"GEORGE W. BOYD,
"*Assistant General Passenger Agent.*"

On the back of the card was published a schedule of the *John Bull* train from New York to Chicago. The leaving time from New York was 10 A.M., April 17, and the time of arrival at Chicago was 3.30 P.M. on April 22.

At the time appointed a goodly company, consisting largely of newspaper men, assembled in the station of the Pennsylvania Railroad in Jersey City. The train consisted of two of the old cars and the veritable *John Bull*, which had been put into running condition recently. The engineer was Albert Herbert, who ran the engine in 1847. The conductor was W. T. Bailey, who began his career as conductor on the old Camden & Amboy Road in 1858, and had been in the service of the Company for 35 years. During that time he never had a passenger injured on any of his trains, and was never suspended nor reprimanded nor subjected the Company to any cost whatsoever on account of accidents. The *John Bull* was on exhibition at the Centennial Exhibition in Philadelphia in 1876, and at that time the following description was published by the Pennsylvania Railroad Company, and had a wide circulation:

"The locomotive *John Bull* was built by Messrs. George

& Robert Stephenson, at Newcastle-upon-Tyne, England, for the Camden & Amboy Railroad & Transportation Company in the year 1831.

"It arrived in Philadelphia in August, 1831, and was transferred to Bordentown, N. J., on September 4, 1831.

ORIGINAL DIMENSIONS.

"Cylinders, 9 in. diameter by 20 in. stroke. One pair of driving-wheels, 4 ft. 6 in. diameter. One pair of wheels, 4 ft. 6 in. diameter, not coupled. Hubs of wheels were of cast iron, the spokes and rims of the wheels of wood. Tires of wrought iron, the weight about 10 tons.

"On arrival at Bordentown it was transferred from the sloop in which it had been brought from Philadelphia by means of wagons to the only piece of permanent track of the Camden & Amboy Railroad Company then completed, and about three-quarters of a mile in length, and about one mile distant from Bordentown. The machinery was then put together, and a tender constructed from a whiskey hogshead placed on a four-wheeled platform car, which had been used by the contractor in the construction of the road. The connection between the pump of the locomotive and the tank was made by means of a leather hose fitted up by a shoemaker in Bordentown. The locomotive was first put in steam, September 15, and several trial trips were made before the first public trial, on the 12th day of November, 1831, Isaac Dripps acting as engineer, Benjamin Higgins as fireman, and R. L. Stevens as general instructor and conductor. The members of the New Jersey Legislature and a number of other prominent persons were among the guests present.

"The *John Bull* remained at Bordentown until the year 1833, when the Camden & Amboy Railroad Company began running their cars by steam power, the road having been previously operated with horses. It was then placed on the road, doing the regular routine service, and continued in successful operation until 1866."

But little can be added to this description at the present time. The two cars were in marked contrast with those at present in use. The seats were a very old-fashioned pattern, and candor compels us to say were very uncomfortable. Evidently when they were made the anatomy of the human form had not been studied with as much care as it has been since by some of the designers of modern seats. The backs of the passengers were supported only at the shoulder blades. Their spinal columns received no attention in those early days of railroading.

The car had an old-fashioned arched roof, without ventilators or windows in it. The height of the floor to the eaves inside was 5 ft. 8 in.; the height of the center was 6 ft. 5 in. The ceiling was therefore destructive to plug hats worn by tall men. The windows consisted of two panes of glass each $8\frac{1}{2} \times 9\frac{1}{2}$ in. Between these was a wooden panel $17 \times 21$ in., which was arranged to lower like the window in an ordinary carriage. The windows themselves were fixed and could not be moved. Above the windows and panels and extending the whole length of the car were a series of pneumonic ventilators. Daylight could be seen through the crevices around almost any of them, and was very suggestive of uncomfortable drafts in cold weather. Small blue curtains were looped up over the windows, and resembled those used in children's play-houses.

The appliance for lighting the car consisted of a tallow candle in a sort of lantern on each end.

That which impressed the passengers on these cars was their extreme rigidity or the roughness of their movement on the track of the Pennsylvania Railroad. In recollecting the early days of traveling, one is apt to attribute the jolting to the rough roads of those early days, but even on the permanent way of the Pennsylvania Railroad these old cars were very uncomfortable.

One feature which attracted attention on the old engine was a sort of a buggy-top on the back end of the tender, which faces toward the rear end of the train. The history of this appliance is that in 1855 a very serious accident happened on the old Camden & Amboy Railroad at Burlington. A passenger train was there backing down over a road crossing, and ran into a carriage and pair of horses belonging to a Dr. Hanagan. The rear car was thrown off the track and the other cars crushed into one another, killing and wounding a large number of passengers. The buggy-top arrangement was then placed on all the tenders, and a lookout was stationed there whenever passenger trains were backed up.

Immense crowds were collected at all the stations between New York and Philadelphia, and the interesting feature was that the arrival of the train was greeted with a broad smile on the faces of each one of the spectators. The general verdict of all passengers on this excursion was that they preferred modern cars to those of the early days.

## PATENALL'S IMPROVED SYKES' SYSTEM OF BLOCK SIGNALS.

By the Johnson Railroad Signal Company, Rahway, N. J.

I.

In describing any system of block signals it is always well to begin with a little preliminary explanation and description of the general principles which govern and require their use, as there are still many readers of an article like this who have very vague ideas about what is called the "block system."

In a general way it may be said that the block system is a consequence of what the natural philosophers used to call the "*impenetrability*" of matter, or "that property in virtue of which two portions of matter cannot at the same time occupy the same portion of space." When the momentum of a rapidly moving railroad train or vehicle impels it to occupy a space simultaneously with another train or vehicle, disastrous consequences are liable to result if they come into collision with each other. The block system has been devised to prevent such accidents, and to exclude more than one train or vehicle from given spaces on railroads at the same time.

The way in which this is done will be understood if we suppose we have a railroad tunnel with two tracks in it, on each of which trains run in only one direction. Obviously no collision can occur in it if, after a train has entered the tunnel on either track, a second train is not allowed to follow it on the same track until the first train has passed out of the tunnel at the opposite end. The same thing will be true if trains are controlled in the same way on any part or division of a double-track railroad.

In the block system this principle is applied to the whole length of the road by dividing it into districts or "block sections," as they are called, with signal stations between them. The sections may be of equal or unequal lengths, as may be convenient for working the traffic.

When a train, engine, or car is on either track in any one of these block sections, all other trains or vehicles are excluded from that track in that section. To illustrate this we will take as an example a portion of a double-track railroad, shown in fig. 1, on which trains run, we will say, "eastward" on one track, and "westward" on the other, as indicated by the darts. It should be understood that the engraving represents a ground plan of the tracks, and that the signaling apparatus, for convenience and clearness, is shown as though it was laid on the ground, and does not appear in its true position in relation to the tracks; neither is it drawn in its true proportions, some of the parts being relatively magnified in size for the purpose of representing them clearly.

Let it be supposed, now, that $R\ R$ and $R'\ R'$ represent two lines of rails of a double-track road, and that trains run, say, westward on one and eastward on the other, and that it is divided into block sections 1, 2, 3, and 4 of any convenient length, by signal stations, $A$, $B$ and $C$, the stations being at the dividing points between the sections, and are connected together by telegraphic or electric communication.

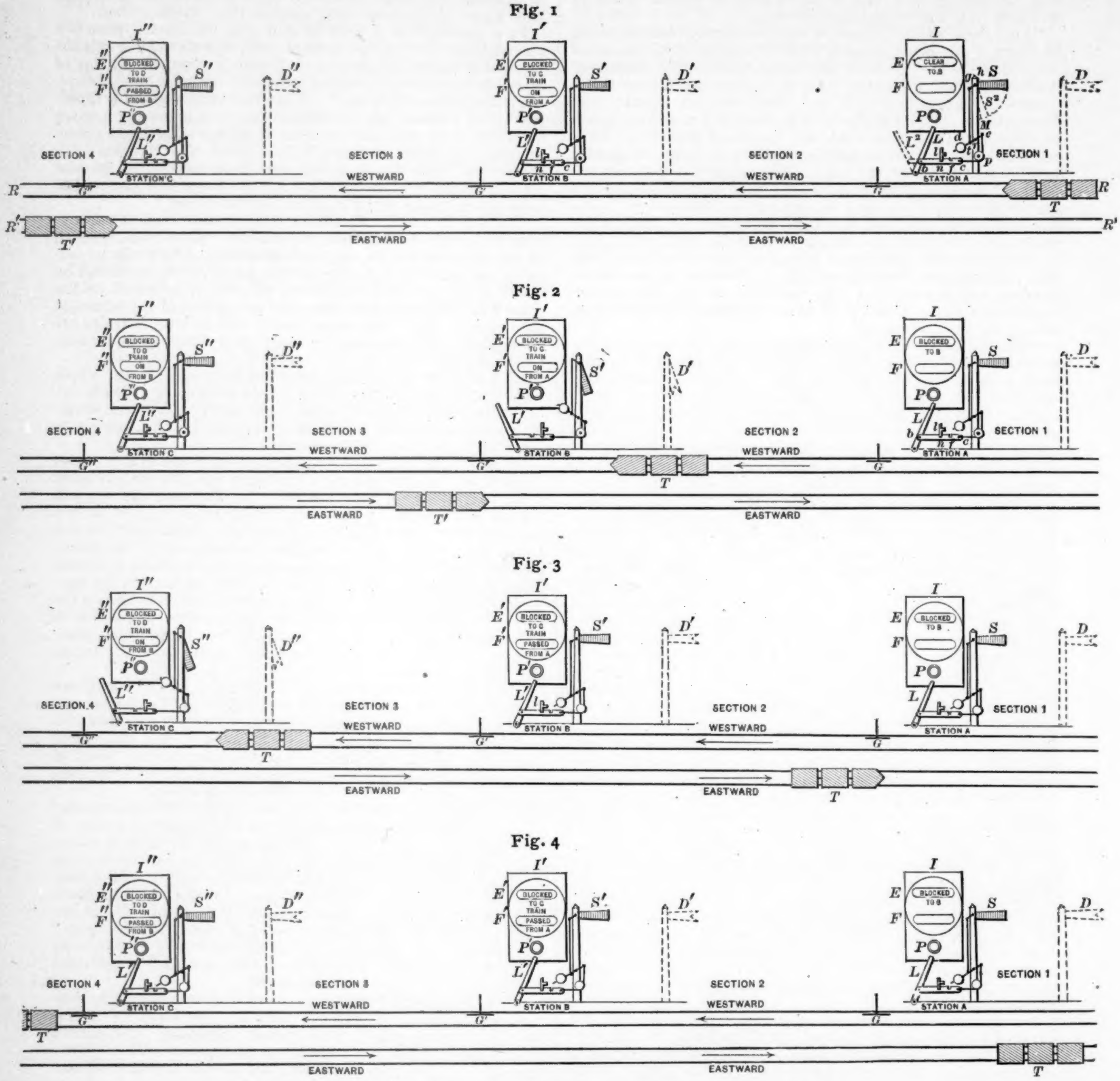
Any form of signals might be used; but it will be supposed that they are of the semaphore type, and consist of a post, $M$ (see station $A$, fig. 1), with a semaphore arm or blade, $S$, which is pivoted to the post at $h$ so that it can be moved like the blade of a knife, and raised and lowered to and from the positions shown by full and dotted lines. When the semaphore $S$ is lowered, or in the position shown by dotted lines $S^2$ at station $A$, it indicates that section 2 ahead of station $A$ is "CLEAR" to station $B$, and when the semaphore is raised, as shown by full lines, it implies "DANGER," or that section 2 is occupied or "fouled," as it is sometimes called.

Usually there are two signals located close to the signal station, one referring to the one track and the other to the line on which trains run in the opposite direction. The signals $S$, $S'$ and $S''$ which are near to the stations are called "home signals." In the engraving, to avoid confusion and complication, only the signals referring to the west-bound track are shown, and will be described. Besides the home signals, other signals, $D$, $D'$ and $D''$, shown by dotted lines in the engraving, are located at a distance of from 1,200 to 1,600 ft. from the home signals, according to the nature of the location and other circumstances. These distant signals will not for the present be referred to, but their purpose will be described later on.

The semaphores are operated by a hand lever, $L$ (see station $A$, fig. 1), which is connected to a bar, $b\ c$, and chain, $c\ p\ e$, which passes over a pulley, $p$, and is connected to another lever, $d\ e$, at $e$. The semaphore is pivoted or suspended on the post by a shaft at $h$, which has a short arm or crank, $h\ g$, attached to it. This is connected to the lever $d\ e$ by a rod,

*g t ; d* is a counterweight which is intended to throw the semaphore up, or to indicate "DANGER" in case the chain or wire *c* or other connection should be broken.

It is a maxim in law that every person must be assumed to be innocent until he has been proved to be guilty. In signaling, experience has shown that safety can be secured only by adopting the reverse of this maxim as a fundamental principle —that is, it must always be assumed that there is danger unless there is positive evidence that there is not, or, in other station *A* in fig. 1 on the west-bound track, and that the signalman at station *A* has learned by telegraph from the signalman at *B* that the last west-bound train which left *A* has passed *B*, and therefore the track between *A* and *B* is unoccupied, or is "CLEAR." There can, therefore, be no danger that the train *T* will run into another one between *A* and *B*, as there is no train there to be run into. Consequently, on the approach of a west-bound train, the signalman at *A* would lower his home signal from the position shown in fig. 1 by full




PATENALL'S IMPROVED SYKES' SYSTEM OF BLOCK SIGNALS.

words, that the line or block section is "CLEAR." For this reason all signals are kept to indicate "DANGER" not only while the section to which they refer is occupied, but until it is required to indicate that the line is "CLEAR" to an approaching train.

Before describing the details of the mechanism which is used in connection with the system of block signals, which is the subject of these articles, an explanation will be given of its general principles and operation.

To do this it will be supposed that a train, *T*, is approaching lines at *S* to that shown by dotted lines at $S^2$. It would then indicate to the engineer of train *T* that the line between *A* and the next station was "CLEAR," and he therefore could go ahead.

As soon as the train passed station *A* then section 2 would be occupied, as shown in fig. 2, and therefore the signalman at *A* would raise his signal to danger and thus "block" section 2, and would not lower his signal again until he is notified by telegraph from *B* that the train *T* has passed *B*, thus leaving section 2 clear. If, when the train approached station *B*, as shown in fig. 2, section 3 was clear, then the signalman at

$B$ would lower his home signal, $S'$, to the position shown which would indicate to the engineer that he may go ahead. As soon as the train passed station $B$ and entered section 3 the signalman at $B$ would raise his signal, as shown at $B$, fig. 3, and thus "block" the section in front of that station, and he would at the same time notify $A$ that section 2 was again clear. When the train approaches station $C$ the same operation would be repeated, and if the line was clear ahead of $C$ the signalman at $C$ would lower his signal, as shown in fig. 3, and would admit the train on section 4, and at the same time notify $B$ that section 3 was clear, and raise his signal, as shown in fig. 4, to block section 4. The same method of operation is employed for trains running on the east-bound track, but, as before explained, separate signals, which are not shown in the engraving, are used for that track.

From this explanation it will be seen that if trains were run in perfect conformity with this system a rear-end collision would be impossible. Unfortunately both human nature and inanimate things seem to have an infinite capacity for falling into error and making mistakes, for neglect of duty, misconception of facts, and general wrong-headedness. A signalman may forget or not notice that a train has entered the section beyond him, and may admit a second one after it. He may go to sleep and not observe whether a train has passed his station or not, and may notify the signalman behind him that the section between them is clear when it is not. Blunders seem to be endowed with superhuman ingenuity, and only a history of railroad accidents would reveal their variety and causes. The occurrence of such accidents has led to the adoption of many ingenious appliances the purpose of which is to avert the consequences of human error in the operation of signals and running of trains. The system of operating signals, which is the subject of this article, has been devised for this purpose.

It has been explained that for the sake of security all signals are placed so as to indicate "DANGER" until safety is assured, and a clear signal is required for an advancing train. In order to make sure that signals will not be lowered unless the line is clear their levers, as, for example, $L$, shown at station $A$, fig. 1, is connected to a locking bar, $b\ c$, which has two notches, $f$ and $n$. A latch, $l$, is arranged so that when the lever is in the position $L$ shown by full lines, the latch will fall into the notch $n$ and lock the lever and signal in that position, which indicates "DANGER." Another notch, $f$, is also provided; and when the lever is thrown over into the position $L^2$ and the signal is thus lowered, the latch $l$ falls into $f$ and locks the lever in that position.

Each station is also provided with two indicator cases, one for each track. In the engravings only one of these, $I$, is shown. These refer to the west-bound track only. It consists of a wooden case, $I$, which has two openings, $E$ and $F$. The indicators $E$, $E'$ and $E''$ refer to the condition of the sections of track beyond or ahead of the stations, while $F$, $F'$ and $F''$ refer to that of the sections in the rear or behind the stations. The signal levers $L$, $L'$ and $L''$ are electrically connected with the indicators. When the signalman at any of the stations, as $A$, throws over the lever $L$ to lower the semaphore and admit a train to section 2, that movement of the lever changes the indicator $E$ at his station so that it will read "BLOCKED to $B$," showing that a train may now enter section 2. This indication is then no longer under $A$'s control—that is, when once he has moved his lever to lower his signal which caused the indicator to read "BLOCKED to $B$," $A$ cannot change that indication, but must depend upon $B$ to do it for him, as will be explained further on.

Before $A$ admits a train on section 2 it should be certain that there is no train on it or that it is "clear." If $A$ depends upon information received by telegraph from $B$, there is always a chance for mistakes. They may misunderstand each other, or forget, go to sleep, or do many other things to which fallible and indolent human nature is prone. For this reason the mechanism of this system of signals is arranged so that when the signal at a station is raised to indicate "danger" it is locked in that position, and the signal man at that station cannot unlock it without the co-operation or consent of the signalman at the next station ahead of him. That is, when $A$'s lever and signal are in the position shown by full lines in fig. 1, $A$ cannot move them until $B$ unlocks $A$'s lever. $B$ does this by means of an electrical connection between $A$ and $B$, which is operated by what is called a "plunger." $P'$, which is a knob or button similar to an ordinary bell-pull, which is arranged in front of his indicator case, $I'$. The construction of this will also be explained hereafter.

Let it be supposed, again, that a train, $T$, is approaching station $A$, fig. 1, and the signal and lever at that station are in the position $S$ and $L$, shown by full lines, and that the indicator $E$ reads "BLOCKED to $B$." $A$ may now ask $B$ by telegraph or ringing an electric bell whether section 2 is clear, and if it is, to unlock his lever, or $B$ may do so without receiving word from $A$, provided section 2 is clear. If it is, $B$ does this by pressing in the knob of the plunger $P'$, which sends an electric current to $A$, which shifts $A$'s indicator, $E$, to indicate "CLEAR to $B$," and unlocks his lever. When $B$ releases the plunger and it springs back, his indicator, $F'$, shifts to "TRAIN ON from $A$," meaning that a train has been admitted to section 2 from $A$, and section 2 is therefore "blocked." When this operation has been performed the plunger is locked, so that it cannot be worked again to admit another train on section 2 until $B$'s lever, $L$, has been pulled over again and returned.

Assuming now that $B$ has unlocked $A$'s lever and changed his indicator, $E$, to read "CLEAR to $B$," $A$ would then throw his lever over and lower his signal to the position $S^2$ shown by dotted lines, which would indicate to the engineer that section 2 was clear and that he can go ahead. It may be repeated that, as this movement of the signal admits a train to section 2, it will simultaneously change the indicator $E$ at station $A$ to read "BLOCKED to $B$," showing that a train has, or is about to, enter on that section.

When the lever is thrown over into the position $L^2$ and the signal is lowered, the latch $l$ drops into the notch $f$ and locks the lever in that position. When the train passes the station it is important that it should get entirely clear of section 1, on which it has been approaching station $A$, before another train is admitted on that section; otherwise a following train might run into the first one before it was off of the section to which they were both admitted at the same time. It is partly to guard against such accidents that what are called automatic track treadles or track instruments $G$ are provided. These consist of a device attached near to the inside of one of the rails, and is actuated by the wheels of trains as they pass over it. The details of the construction of such instruments will be described later. It will be sufficient to say now that it is electrically connected with the locking parts of the lever $L$, so that when the train passes over the instrument $G$ the lever, which has been locked in the position $L^2$ when the signal was lowered, is then unlocked and can be returned home and the signal restored to the danger position, where it is again locked by the latch $l$ dropping into the notch $n$.

It should be observed that $A$'s lever and signal are now locked in the "DANGER" position, so that he cannot lower the latter to admit another train to section 2 until it is again unlocked, and $B$'s plunger is also locked, so that he cannot release $A$'s lever, and therefore it is impossible to admit another train on section 2 until $B$'s plunger is unlocked.

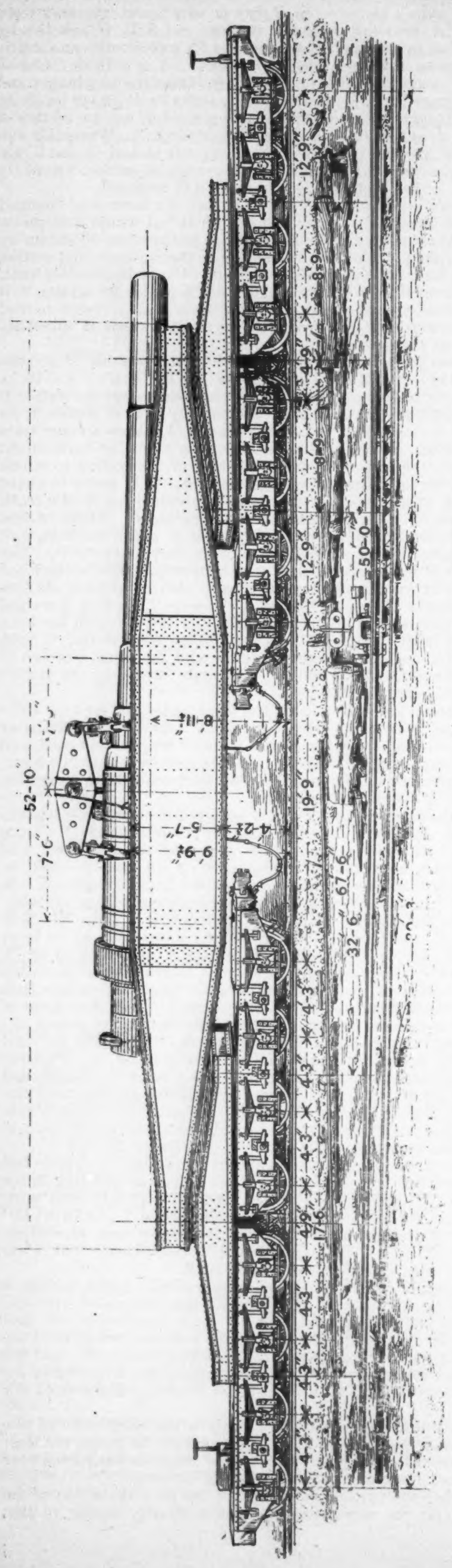
As the train approaches $B$, if section 3 is clear and $C$ has unlocked $B$'s lever, his indicator, $E'$, would read, "CLEAR to $C$," and $B$ can then throw his lever over, and we will have the condition of things shown in fig. 2—that is, $B$ has lowered his signal $S'$ to admit the train to section 3. In doing this the movement of his lever has changed his indicator, $E'$, to read "BLOCKED to $C$," showing that a train has or is about to enter section 3, and $B$'s signal is lowered and his lever $L'$ is locked in the position in which it is shown in fig. 2. When the train passes over the track instrument $G'$ at station $B$ the action of the wheels unlocks $B$'s lever, and it may then be returned home and his signal lowered. This movement of his lever releases his plunger, $P$, and enables him to unlock $A$'s lever and change his indicator, $E$, to read "CLEAR to $B$," and we then would have the condition shown in fig. 3. $B$'s lever then remains locked until the train has passed $C$'s treadle, and $C$ has pressed in his plunger, $P''$. Should another train approach $B$ from $A$ before $C$ has thus unlocked $B$'s lever, $B$ cannot lower his semaphore even should he attempt to do so, and the train must stop until $B$'s lever is unlocked by $C$.

$A$ may now ask $B$ by telegraph or by ringing an electric bell to relock his lever again, and $B$ can do this by pressing in the plunger $P'$, which, as explained, sends an electric current to $A$, unlocks $A$'s lever, shifts $A$'s indicator, $E$, to "CLEAR to $B$." When $B$ releases the plunger and it springs back, his indicator, $F$, shifts to "Train ON from $A$," which means that $A$ has or may admit another train to section 2.

The plunger is then locked automatically again, so that it cannot be worked until $B$'s lever, $L'$, has been pulled over and another train has passed over his track instrument, $G'$, and the lever returned. The lever then remains locked until the train on section 3 has passed $C$'s track instrument, $G''$, and unlocked $C$'s lever, and it has been returned home and released his plunger. He will then be enabled to plunge and unlock $B$'s lever.

It will thus be seen that not only is the *concurrence* of two signalmen required before a clear signal can be given, but their co-operation is not possible until *after* the train has passed over the track instrument of the station in advance.

During the further movement of the train the action of the signals at the succeeding stations is exactly similar to that




CAR OF 285,000 LBS. CAPACITY FOR THE TRANSPORTATION OF HEAVY GUNS.

which has been explained. When it approaches station *C*, as shown in fig. 3, if section 4 is clear, and the signalman beyond has released *C's* signal, he lowers it into the position in which it is shown. This movement changes *C's* indicator, *E''*, from "CLEAR" to "BLOCKED," to show that a train has been admitted to section 3. When the train has passed over the track instrument *G''* it unlocks *C's* lever, *L''*, and it is returned home, as shown in fig. 4. At the same time the indicator *E''* at station *C* has been changed from "CLEAR" to "BLOCKED," and *F''* from "Train ON from *B''*" to "Train PASSED from *B*." The lever *L'* at station *B* may now be unlocked by *C* and the indicator *E'* at *B* changed from "BLOCKED" to "CLEAR" on the approach of another train.

The movement and control of trains and the action of the signals on the east-bound track is exactly similar to that which has been described, it being understood that the whole apparatus is duplicated—that is, that there are separate levers, signals, indicators, and treadles for each track.

The object of the distant signals *D*, *D'* and *D''* is to give the engineer warning of danger at a sufficient distance from the stations, so that he can control his train before reaching the home signal and the section which is not clear. The distant signals are operated by separate levers, not shown in the engravings, which are arranged in such a way that to indicate danger the movement of the distant signal always precedes that of the home signal—that is, if a section is blocked, the distant signal is raised first to protect the rear of the train. To admit a train they are moved in the reverse order—that is, the home signal is lowered first and the distant signal afterward.

From what has been said it will be seen, then, that with this system of signals an engineer, when he approaches a station, should be controlled first by the distant signal and next by the home signal. A signalman at any station—as *A*, for example—cannot lower his signals to indicate that the line is clear until the signalman at *B*, next in advance of him, has notified *A* that the section between them is clear, and has unlocked *A's* signal lever. If *A* has admitted a train on the section, *B* cannot give a signal to *A* that the line is clear and unlock his lever until the train on the section has passed *B's* station and operated his track treadle. After this operation has been performed, *and not before*, *B* can notify *A* that the section is clear, and can then unlock *A's* lever. *A* can *then* lower his signals, but not until *after* these operations have been performed.

In other words, the engineer is governed by the signals, the signalman is controlled by the man at the next station ahead of him, and he is governed by the action of the train on his track treadle. This, it is thought, gives the highest degree of security which has yet been attained by any system of signaling.

In one or more other articles the mechanism employed with this system of signaling will be described.

## CAR FOR CARRYING HEAVY GUNS.

WE illustrate the car which has recently been built by the Pennsylvania Railroad Company for carrying the heavy guns intended for the Chicago Exposition. It was built more particularly for the big gun sent over by Krupp. It is shown with this gun in position, just as it was loaded from the steamer at the Sparrow Point Iron Works, at Baltimore, Md. It has a capacity of 285,000 lbs., and is built entirely of boiler steel; the center plates and center bearings being steel castings. It consists, as may be seen by referring to the engraving, of a major bridge, two minor bridges, and four eight-wheel cars. The gun rests in the major bridge on two supports designed to closely fit its perimeter. In addition to these two supports, to avoid any vibration while in transport, the muzzle is secured by wedge shaped oak blocks set in cast-iron shoes and drawn up to the muzzle by means of right and left-hand screws. The major bridge is 50 ft. from center to center of supports, and rests directly on the side bearings, while, on the other hand, the minor bridges are supported by their respective center plates.

The cars have been designed so as to combine strength with flexibility, and are equipped with Janney couplers and draft rigging specially constructed for strength.

The journals are $4\frac{1}{2}$ in. × 9 in.; $37\frac{1}{2}$-in. wheels with wrought-iron centers and steel tires are used.

Each car has a 14-in. Westinghouse air-brake cylinder with brake on all wheels, and National hollow brake beams with Christie brake heads and shoes.

The load on cars is thoroughly equalized by 32 elliptic springs of 36-in. span, each spring having 18 leaves $3\frac{1}{2}$ in. wide and $\frac{3}{8}$ in. thick.

The extreme length of car is 90 ft. 9 in.; extreme width, 9 ft. 10 in.; extreme height to top of bridge, 9 ft. $9\frac{3}{4}$ in.

## AMERICAN AND ENGLISH LOCOMOTIVES.

(*Continued from page* 168.)

IN this number of the AMERICAN ENGINEER we give engravings of the cylinders of the American and of the English locomotives which have formed the subject of this series of articles. The following are the specifications of the cylinders of the American engine:

CYLINDERS.

Of close-grained hard charcoal iron. Cast with half saddle attached, the right and left cylinders from the same pattern and interchangeable. Fitted together in a substantial manner, and securely bolted and keyed to frame. Valve face and steam-chest seat raised above face of cylinder to allow for wear. Cylinders oiled from Nathan No. 9 double sight feed lubricator placed in cab, with copper pipe under boiler lagging to steam-chest.

PISTONS.

Made with removable follower, and fitted with approved cast-iron steam packing. Piston-rods of hammered iron.

### SPECIFICATIONS OF CYLINDERS OF ENGLISH EXPRESS LOCOMOTIVE.

CYLINDERS.

The cylinders are to be 19 in. in diameter when finished, with a stroke of 26 in. The steam ports are to be 16 in. long and 1⅝ in. wide. The exhaust port is to be 16 in. long and 3 in. wide. The bars are to be 1½ in. wide. The cylinders are to be made of best close-grained, hard, strong cast iron; they must be as hard as they can be made, to allow of their being properly fitted and finished, and must be perfectly free from honeycomb or any other defect of material or workmanship; they must be truly bored out, the front end being bell mouthed. All the joints, covers and surfaces are to be planed or turned and scraped to a true surface, so that a perfect joint can be obtained. All studs are to be tightly screwed. The cylinders are to be made with loose covers at both ends, provision being made on the back cover for carrying the slide bar. They are to be set in a horizontal line, placed at a distance apart of 6 ft. 2½ in. from center to center, with steam-chest on side, as shown on drawing. The holes in the frames and flanges of the cylinders are to be carefully rimmered. When the cylinders are correctly set to their places they are to be firmly secured to the frames by turned bolts 1¼ in. in diameter driven home to a tight fit. The cylinders are to be covered with lagging and clothing plates 14 Standard W. G. thick. The front and back cylinder covers are to be protected by clothing plates secured as shown. The cylinders before being fixed in position to be tested in the presence of the Railway Company's Locomotive Superintendent or his Inspector by hydraulic pressure to 200 lbs. per square inch. All joints must be perfectly tight under this pressure; the front and back cylinder covers and cylinders generally to be exactly to the drawing.

PISTON AND PISTON-RODS.

The pistons are to be made of cast steel, free from honeycomb or any other defects, to the form and dimensions shown on drawing, and are to be fitted accurately to the cone of the rods, and secured thereon by gun-metal nuts formed with collars and taper steel pins through the nut. The piston head is to be an easy fit in the cylinder; the packing rings are to be three in number, of cast iron ⅝ in. wide, ½ in. thick, and turned all over. The rings are to be turned larger than the diameter of the cylinders, then to be cut and sprung in to fit the bore in the cylinders, and are to be prevented from turning round in the piston by dowel pins fixed in the position shown. When finished, the whole must be an easy and accurate fit, so that the finished rod and piston can be moved readily backward and forward in the cylinder. The piston-rods are arranged to work through both front and hind cylinder covers, and to be 3⅝ in. diameter at back end and 2½ in. at front end, and are to be forged from the very best cast steel of approved make, with a breaking strength of 30 tons per square inch; they are to be truly fitted to the heads, and are to be tapered where they enter the cross-head, and to which they are to be secured by cotters of mild Swedish steel. Full particulars of the various dimensions and tapers are to be obtained by reference to the full size drawings.

METALLIC PACKING.

Both piston-rods to be fitted with the United States Metallic Packing Company's packing, which is to be obtained from that company. The hind cylinder cover is to be arranged, as shown on the detail drawing, to suit this packing, and the front cylinder cover to have a stuffing-box, which is also fully shown on the drawing.

SLIDE VALVE.

The slide valve is to be of the best Stone's bronze, to be made exactly as shown on the drawing, and with recesses in its working face.

VALVE SPINDLES.

The valve spindles and buckles are to be of best Yorkshire iron and of the dimensions shown on drawing. The spindles are to be guided by gun-metal glands and bushes through the steam-chest; the valve spindle is to be tapered where it enters the valve rod, and is to be secured by a cotter of mild Swedish steel.

Whatever the opinions of our readers may be of the relative merits of the construction of the two engines referred to herein, they will agree with us probably in thinking that the specifications of the English locomotive are a great deal fuller, more explicit and complete than those of its American contemporary.

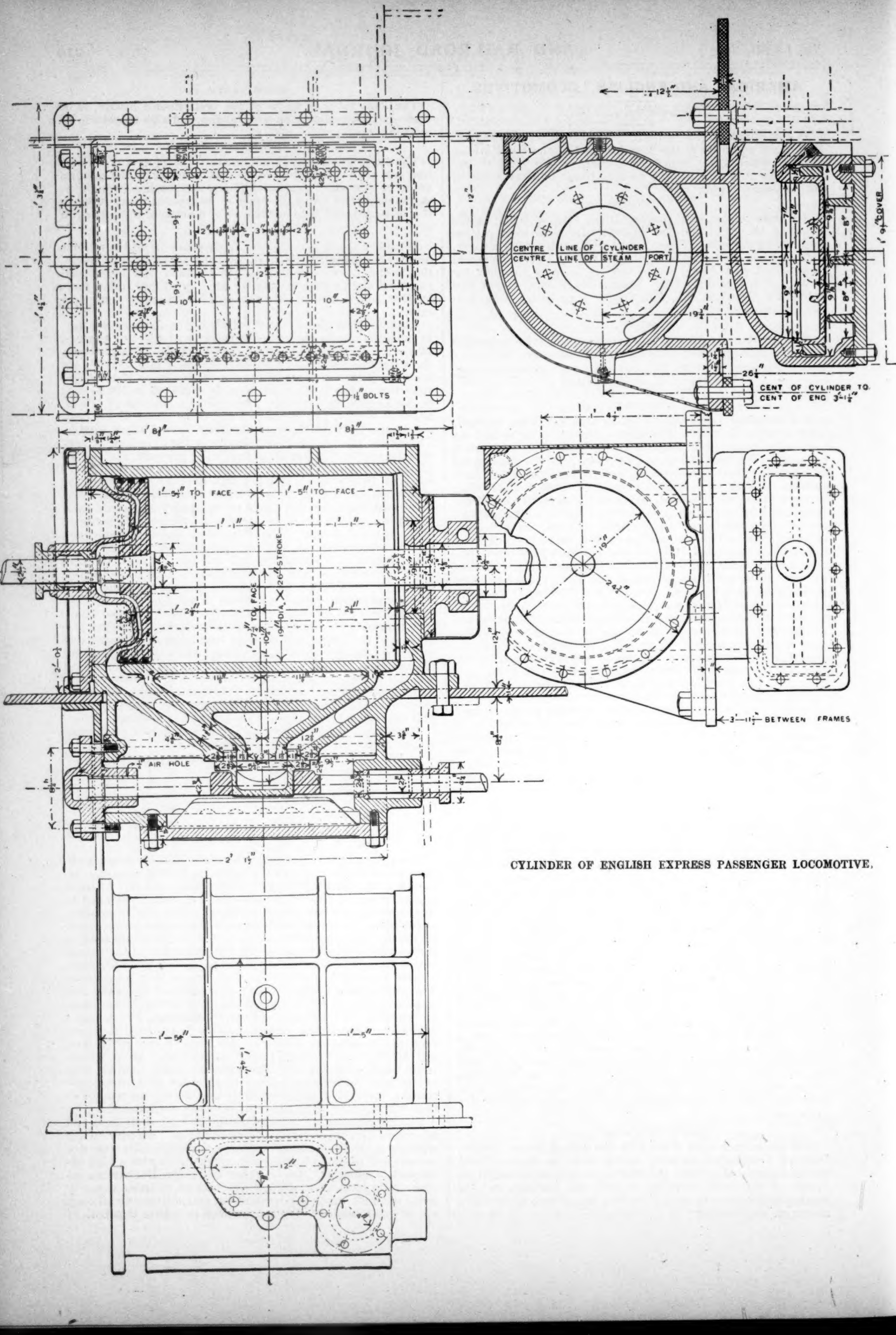
Attention has already been called, in our January number, to the difference in the cylinder capacity of the two engines. It was shown there that taking the size of the driving-wheels, the weight on them, and the boiler pressure into account, the relative cylinder capacity of the American engine, if compared with that of the English machine, is as 460.65 to 590.4—that is, the English cylinders, in proportion to the size of wheel, adhesive weight, and steam pressure, have about 28 per cent. more capacity than those of the New York Central engine. Taking the average effective pressure in the cylinders, at very slow speeds, at 90 per cent. of the boiler pressure, the pistons of the New York Central engine would then exert a tractive force of 16,614 lbs., which is a little over 20 per cent. of the weight on the driving-wheels. The pistons of the London & Southwestern engine, calculated on the same basis, would exert 17,394 lbs., which would be equal to a little over 25 per cent. of the adhesive weight. The interesting question then comes up, Which engine has the best proportioned cylinders? If the cylinders of a locomotive are too large, it then becomes what locomotive runners call "slippery"—that is, the wheels slip before or as soon as full boiler pressure is admitted to them, even when cutting off steam at considerably less than full stroke. On the other hand, if the cylinders are too small, it is necessary to admit steam to them during the larger proportion of the stroke, and there is thus a loss of economy due to the fact that the steam is not worked with a sufficient amount of expansion. There can be no doubt that the maximum load which a locomotive will pull is diminished if it is over-cylindered, owing to the fact that the full steam pressure cannot be exerted on the pistons for a sufficiently long time to start or pull the load without slipping the wheels.

The following figures relating to the adhesion of locomotive wheels on the rails are easily remembered:

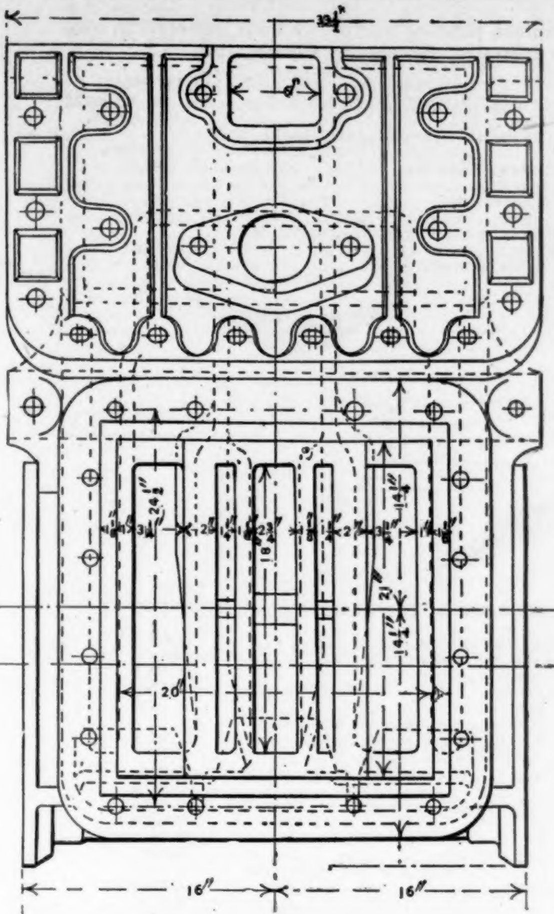
| | | | | |
|---|---|---|---|---|
| On dry sanded rails adhesion | = ⅓ the insistent weight. | | | |
| " " rails not sanded adhesion | = ¼ | " | " | " |
| " rails in ordinary condition adhesion | = ⅕ | " | " | " |
| " rails in bad condition adhesion | = ⅙ | " | " | " |

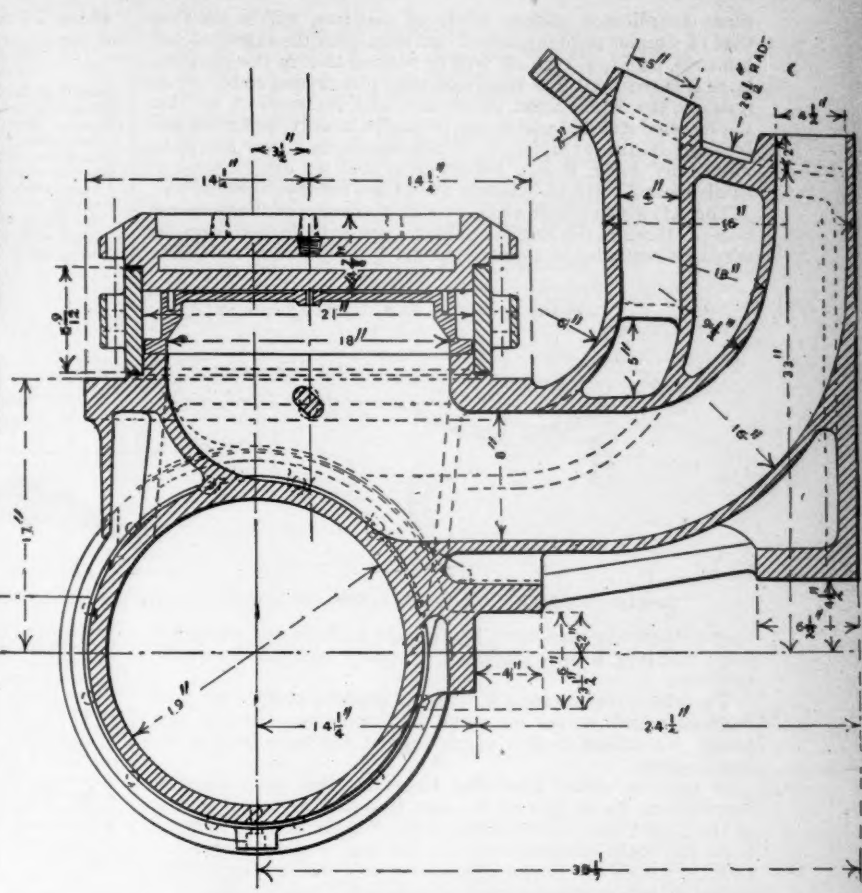
From these figures it would appear that Mr. Buchanan's engine would not be able to slip its wheels if their adhesion exceeded ⅕ the weight on the rails below them, and Mr. Adams's engine could not do so if the adhesion was over ¼. It must be remembered, however, that the tractive power of a locomotive, as calculated by the ordinary rules, is the *average* power exerted during one revolution of the wheels. The actual rotative force exerted by the steam at the circumference of the wheels varies through the whole revolution. At one point the force exerted is nearly or quite 20 per cent. greater than the *average*. This occurs when both cranks are in front of the axles and stand at angles of 45° with horizontal and perpendicular lines. In working with its maximum steam pressure, Mr. Adams's engine therefore would exert a tractive force equal to 30 per cent. of the adhesive weight at this point in each revolution, and Mr. Buchanan's would exert 24 per cent. If the wheels begin to slip at this or any other point in their revolution, they are liable to continue to do so during the rest of it, even if the tractive force or rotative effect is less during the remainder than it was at the point where the slipping commenced.

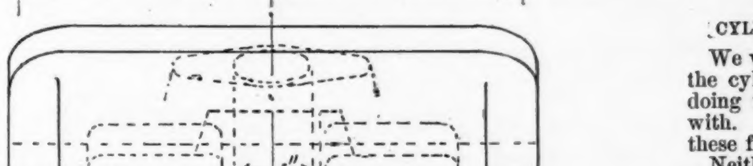
The inference may, therefore, be drawn from these facts and inferences that Mr. Adams's engine would be "slippery" when working up to its maximum capacity unless the rails were dry and sanded, or in the best possible condition to give a high coefficient of adhesion. On the other hand, Mr. Buchanan's engine would seem to be slightly deficient in cylinder capacity when the rails are in *good* condition, and still more so if they are dry and sanded. We are inclined to believe that both of



CYLINDER OF ENGLISH EXPRESS PASSENGER LOCOMOTIVE.








CYLINDER OF AMERICAN EXPRESS PASSENGER LOCOMOTIVE.

the engines would be improved if Messrs. Buchanan and Adams were to swap cylinders, so that the heavier engine would have 26 in. stroke and the lighter one 24 in.

We will not refer in this article to the method of fastening the cylinders to the frames and smoke-box, as the method of doing this is not shown very clearly in the engravings herewith. In other illustrations which it is intended to publish these features will be clearly represented.

Neither will we have anything to say here of the advantages and disadvantages of placing the steam chests and slide valves on the sides of the cylinders and between the frames, as we will reserve comment on this feature until next month, when we expect to give illustrations of the valve gear, and the whole subject will then be discussed in one article.

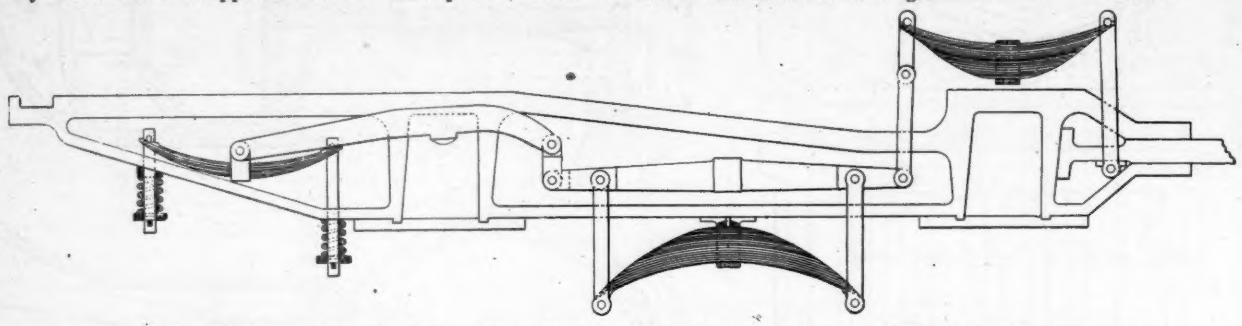
The attention of our readers is called to that feature in Mr. Adams's specifications of the cylinders of his engine which requires that " before being fixed in position they are to be tested . . . by hydraulic pressure to 200 lbs. per square inch. All joints must be perfectly tight under this pressure." This test is never applied in this country, or if it is, we have never heard of it. It seems to be an excellent precaution to guard against defective castings and workmanship. We might imitate our English brethren in this particular to our own advantage. It seems, though, that the difference of only 25 lbs. between the test pressure and the boiler pressure is hardly enough for a " factor of safety."

A comparison of tests of the cast iron used in the cylinders made here and made there would be interesting, to show the difference in the quality of the material used here and in England.

The piston heads of the English engine, it will be seen from the specifications, are made of cast steel. Those in the American engine are cast iron. The former is also a simpler and lighter structure than the latter, but it makes a somewhat complicated-shaped cylinder head necessary to conform to its contour. Probably most American master mechanics would be in doubt about cast-steel piston heads wearing satisfactorily if they came in contact with the inside surface of the cylinders. Is it this apprehension that has led to the extension of the piston-rods of the English engine through the front cylinder-head? Pistons on our engines are run with entire satisfaction without the extension of their rods. Now, if American cast-iron pistons will run satisfactorily without the extended piston-rods, packing, etc., they are cheaper and simpler—that is, the cost of our

more complicated pistons made of cast iron will be less than that of simpler pistons made of cast steel, plus the extended piston-rods, packing, etc. It will be noticed that in the specifications it is required that these cast-steel pistons and rods "when finished, the whole must be an easy and accurate fit, so that the finished rod and piston can be moved readily backward and forward in the cylinder." If this means that they are to be moved by hand, it is a requirement that we are inclined to think most American builders would not readily conform to.

The American piston-rods are specified to be of "hammered iron;" those of the English engine "are to be forged from the very best cast steel of approved make." Steel piston-rods have

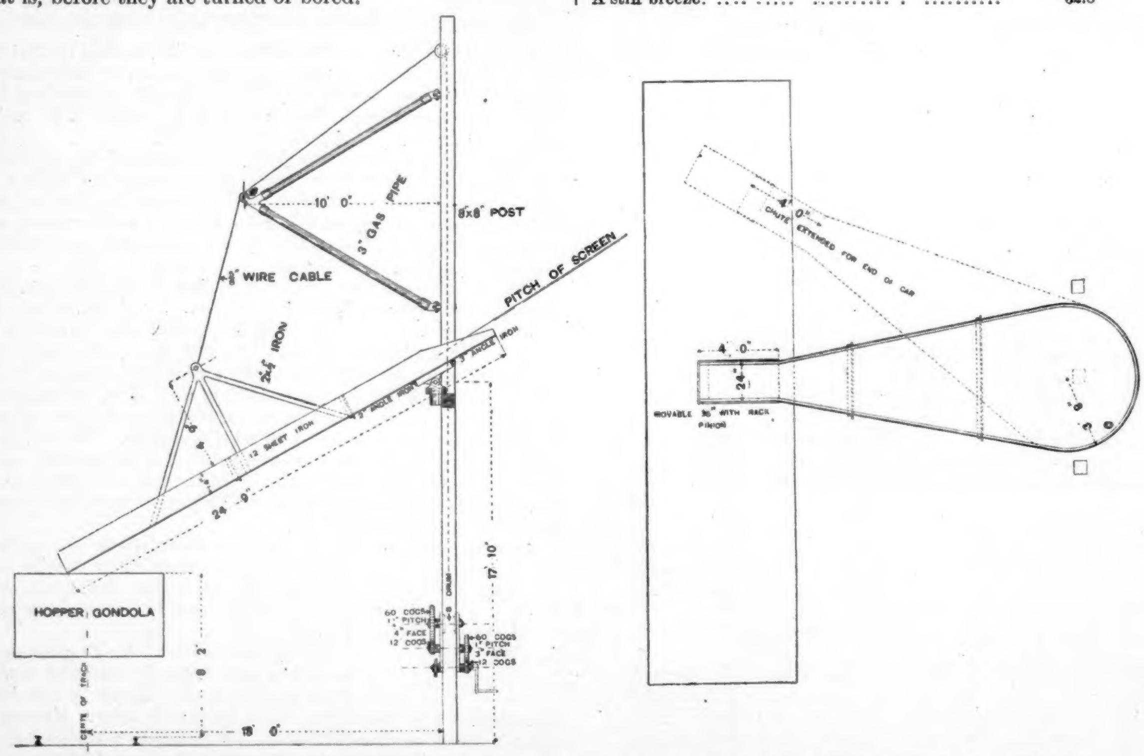


ARRANGEMENT OF EQUALIZERS ON FOUR-COUPLED ENGINES, DELAWARE & HUDSON CANAL COMPANY.

been extensively used here, but appear to have lost ground of late; and iron is now preferred by many locomotive superintendents.

The piston-rod packing is "United States metallic" for both engines, which leaves no room for discussion. In our next article we expect to give engravings of the valve gear of the two engines.

It may be added here that since our last issue we have learned that the weight of the cast-iron driving-wheel centers of the New York Central engine, including the counterweights, is for the main or front wheels, 3,254 lbs., and for the rear or trailing wheels, 3,147 lbs. This is the weight of castings rough—that is, before they are turned or bored.




SWINGING COAL SHUTE AT QUAKER STREET, ON DELAWARE & HUDSON CANAL COMPANY RAILROAD.

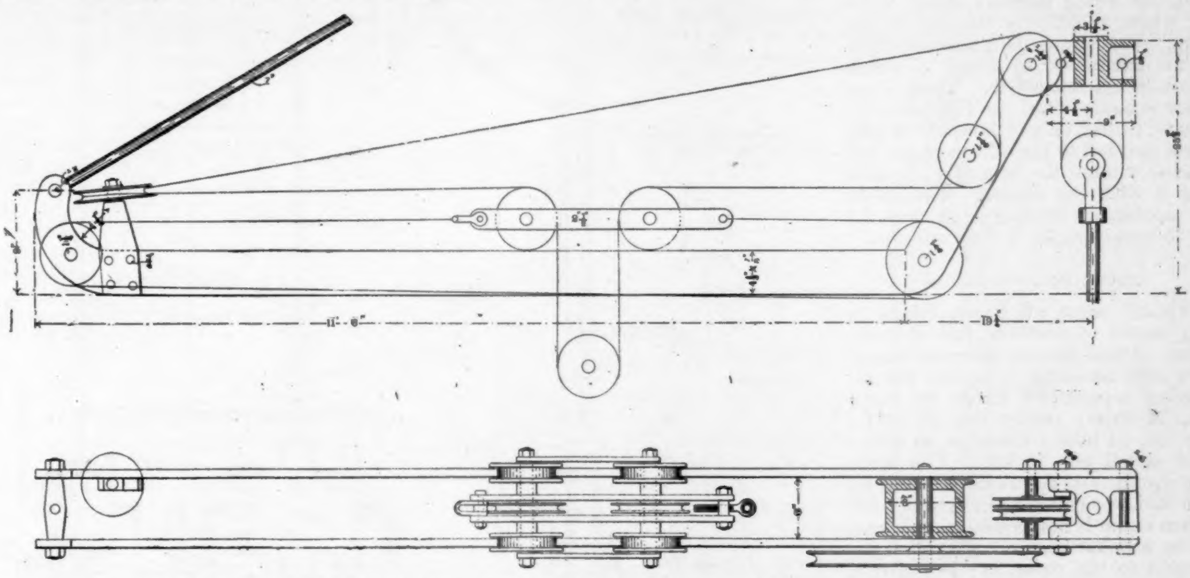
## SOME EXTREME SPEEDS.

Mr. James Jackson has taken the pains to gather together in a tabulated form a large number of speeds, from the growth of finger nails to the velocity of electricity, taking up that of winds, projectiles, stars, etc. He has drawn up a list of about 300 velocities in this manner, taken from numerous authors, which we cannot produce entire, but limit ourselves to some of the more interesting figures given in his table.

| | Ft. per second. |
|---|---|
| Growth of finger nails | .000,000,006,56 |
| Growth of bamboo | .000,020,992 |
| Flow of blood in the capillary passages of the human system | .000,024,6 |
| Fall of the earth toward the sun | .009,84 |
| Reading of current text | .124,64 |
| A man climbing a staircase | .492 |
| Progress of the eel | .623,2 |
| Combustion of powder in a breech of a cannon of large calibre | 1.049,6 |
| Flow of blood in the aorta of a dog | 1.312 |
| Man walking 2½ miles an hour | 3.640,8 |
| Man swimming 300 feet in 65 seconds | 4.61 |
| Man walking 3¾ miles an hour | 5.444,8 |
| Flow of a rapid river | 13.12 |
| Vessel at nine knots an hour | 15.186,4 |
| Maximum of the inaugural train of the Manchester and Liverpool R. R., on September 15, 1830 | 17.580,8 |
| A racing boat, Cambridge and Oxford, 1873 | 23.88 |
| Ordinary wind | 16 40 to 19.68 |
| A fresh breeze | 21.943,2 |
| A wave 100 feet high by 900 feet long | 22.369,6 |
| Ordinary flight of a fly | 24.993,6 |
| A blow of the fist | 27.88 |
| Skater upon roller skates | 30.996 |
| Fall of a body toward the surface of the earth at the end of one second | 32.176,8 |
| A stiff breeze | 32.8 |
| Drops of rain | 36.08 |
| Skater upon ice | 39.819,2 |
| Velocipede | 40.00 |
| Flight of a pelican | 21.976 to 51.332 |
| A railroad train at 37¼ miles per hour | 54.677,6 |
| Flight of the quail | 58.384 |
| Self-propelling torpedo | 59.04 |
| A horse on a gallop | 60.368,8 |
| A tempest | 82 to 98.40 |
| Fall of a body toward the surface of the earth after a fall of 328 feet | 145.471,2 |

| | |
|---|---|
| A storm that will uproot trees | 147.60 |
| Great waves of the ocean | 150.312,4 |
| Flight of the swallow | 219.76 |
| Transmission of sensation in the nervous system of a man | 432 96 |
| Initial velocity of a ball at the muzzle of a gun | 675.68 |
| Fall of a body at the surface of the sun after a fall of one second | 884.845,6 |
| Sound in quiet, dry air | 1,086.008 |
| Initial velocity of a ball at the muzzle of a field gun | 2,033 6 |
| Revolution of the moon about the earth | 3,181.6 |
| Initial velocity of a cannon ball | 3,322.64 |
| Sound in bronze and in oak wood | 11,899.84 |
| Aerolite falling 14th of May, 1864, at Tarn-et-Garonne | 65,600. |
| Revolution of the earth about the sun | 96,822.32 |
| Halley's comet at perihelion | 1,289,040. |
| Revolution of the visible satellite of Sirius | 4,031,100. |
| Electricity on the submarine cable | 3,120,000. |
| Electricity on telegraph wire | 118,080,000. |
| Lightning in a solar spot | 656,000,000. |
| Light in water | 738,000,000. |
| Light in air | 984,000.000. |
| Electric current carrying the discharge of a Leyden jar over a copper wire $\frac{1}{10}$ of an inch in diameter | 1,520,280,000. |

—*Revue Scientifique.*



OIL-HOUSE CRANE, DELAWARE & HUDSON CANAL COMPANY'S SHOPS, GREEN ISLAND, N. Y.

## CYLINDER SIZES OF LAKE ENGINES.

BELOW is given the sizes of a number of lake engines and the boats in which they are placed. In addition to the direct information given, the list shows the lake practice of proportioning cylinders. The engines are all triple expansion, except where otherwise designated.

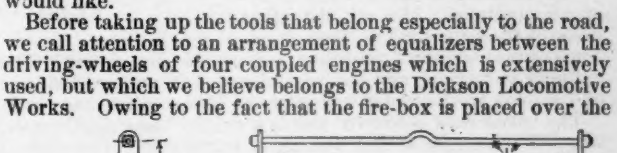
28, 42½ and 72 in. × 54 in. stroke—*Owego* and *Chemung.*
26, 42 and 70 in. × 42 in. stroke—*Christopher Columbus.*
25, 36, 51½ and 74 in. × 42 in. stroke, quadruple—two in each of the twin-screw Northern steamers.
42 and 66 in. × 132 in. stroke, compound vertical beam—*City of Alpena* and *City of Mackinac.*
26, 42 and 66 in. × 72 in. stroke, inclined triple expansion for paddle wheels—*City of Toledo.*
24, 39 and 63 in. × 48 in. stroke—*Maritana* and *Mariposa.*
24, 38 and 61 in. × 42 in. stroke—six Northern steamers, six Minnesota steamers, six Menominee steamers, five Lehigh steamers, two Mutual steamers, *Pontiac, Aurora* and *Bradley.*
23, 36 and 62 in. × 48 in. stroke—*Hudson.*
23, 37 and 62 in. × 44 in. stroke—*Merida* and *W. H. Gilbert.*
23, 38 and 62 in. × 36 in. stroke—*Manitou.*
23, 37½ and 63 in. × 44 in. stroke—*Centurion.*
23, 37 and 62 in. × 42 in. stroke—*Emily P. Weed* and *C. B. Lockwood.*
22, 35 and 56 in. × 44 in. stroke—*E. C. Pope.*
21, 33½ and 57 in. × 42 in. stroke—*Fred Pabst.*
21, 33 and 56 in. × 42 in. stroke—*Volunteer.*
20½, 32 and 54 in. × 42 in. stroke—*Roumania.*
20, 32 and 52 in × 42 in. stroke—*Olympia, Samuel Mitchell* and *Schuylkill.*
20, 32 and 52 in × 36 in. stroke—two in twin-screw steamer *Virginia.*
20, 32 and 54 in. × 42 in. stroke—*Alexander Nimick* and *Helena.*
20, 33 and 54 in. × 42 in. stroke—*Pioneer.*
20, 32 and 52 in. × 40 in. stroke—*Sitka* and *Gogebic.*
20, 33 and 54 in. × 40 in. stroke—*Yumna.*
20, 31 and 52 in. × 40 in. stroke—*Neshoto, J. C. Lockwood* and *Frontenac.*
19, 32 and 52 in. × 45 in. stroke—*Brazil.*
19, 30 and 52 in. × 40 in. stroke—*George W. Roby, Tom Adams, Philip Minch, Lackawanna* and *Scranton.*
18, 30 and 48 in. × 40 in. stroke—*Gilchrist.*
17, 29 and 47 in. × 36 in. stroke—*La Salle, Joliet, Wawatam, Griffin, Wade* and *Hesper.*
17, 28 and 46 in. × 30 in. stroke—*Rosedale.*
15¼, 26 and 42 in. × 22 in. stroke—*Wadena.*
15, 25 and 42 in. × 30 in. stroke—*Cadillac.*

—*Marine Review.*

## SPECIAL TOOLS IN USE ON THE DELAWARE & HUDSON CANAL COMPANY'S RAILROAD.

IN our last issue we illustrated a number of special tools that have been designed and constructed in the shops of the Delaware & Hudson Canal Company, and we continue the subject with illustrations of a few more, regretting, however, that it is impossible, from lack of space, to present as many as we would like.

Before taking up the tools that belong especially to the road, we call attention to an arrangement of equalizers between the driving-wheels of four coupled engines which is extensively used, but which we believe belongs to the Dickson Locomotive Works. Owing to the fact that the fire-box is placed over the frames and that the latter have been cut away, it is necessary to place the springs below. A spring is therefore placed over the front axle-box in the ordinary way, and this spring is attached to the frame and the regular equalizer by hangers of the usual construction. The main equalizer, however, is floating—that is, it has no connection with the frame direct, but instead is coupled to a heavy spring having 17 leaves, which is placed below the lower bar of the frame and against which it bears. On the rear driving-box there is a lever with unequal legs, the longer one of which is coupled to a light spring, which is, in turn, attached to the frame through coil springs. The system produces a very easy riding engine. The use of the auxiliary coil springs under the frame at the end has



BARREL RACK FOR OIL-HOUSE CRANE.

come to be recognized as the proper thing where easy riding is aimed at, and the addition of the equalizing spring simply adds to what has already been done. The equalizing lever serves the purpose of holding the spring in position and protects it from all surging strains which it would receive were it not so protected.

### SWINGING COALING SHUTE.

At Quaker Street there is a very convenient swinging coaling shute for loading gondola cars. The general construction will be easily understood from the engravings. The inclined screen delivers the coal upon a shute that is 7 ft. 4 in. wide at the upper end, but which narrows down to 24 in. where it delivers the coal to the cars. This shute has a movable slide at the narrow end, by means of which it can be extended 36 in. Thus, when a car is hauled into position, the coal can be turned on and the shute swung from one end to the other and the car loaded without the necessity of moving it with the engine. The shute is capable of loading a gondola car of 25 tons capacity in four minutes.

### CRANE FOR OIL HOUSE.

The oil room at Green Island is the model of neatness and convenience. Along one side there are ranged five large tanks for oil having the following capacities: Tank for valve oil, 34 bbls.; engine oil, 35 bbls.; car oil, 34 bbls.; kerosene, 35 bbls.; and signal oil, 15 bbls. The tanks are square, and the room is heated by the McElroy commingler system; but when steam is not available, it is heated by a Baker heater. The oil is delivered to the room in the barrels, which are hoisted to the top of the tanks by the crane illustrated, and the oil runs directly into them. The crane consists of two bars of wrought iron 4½ in. × ⅜ in. bent to the form shown. They are pivoted to a center bolted to the wall and stayed by a ⅞-in. rod. A traveler which may be racked in and out completes the crane rigging.

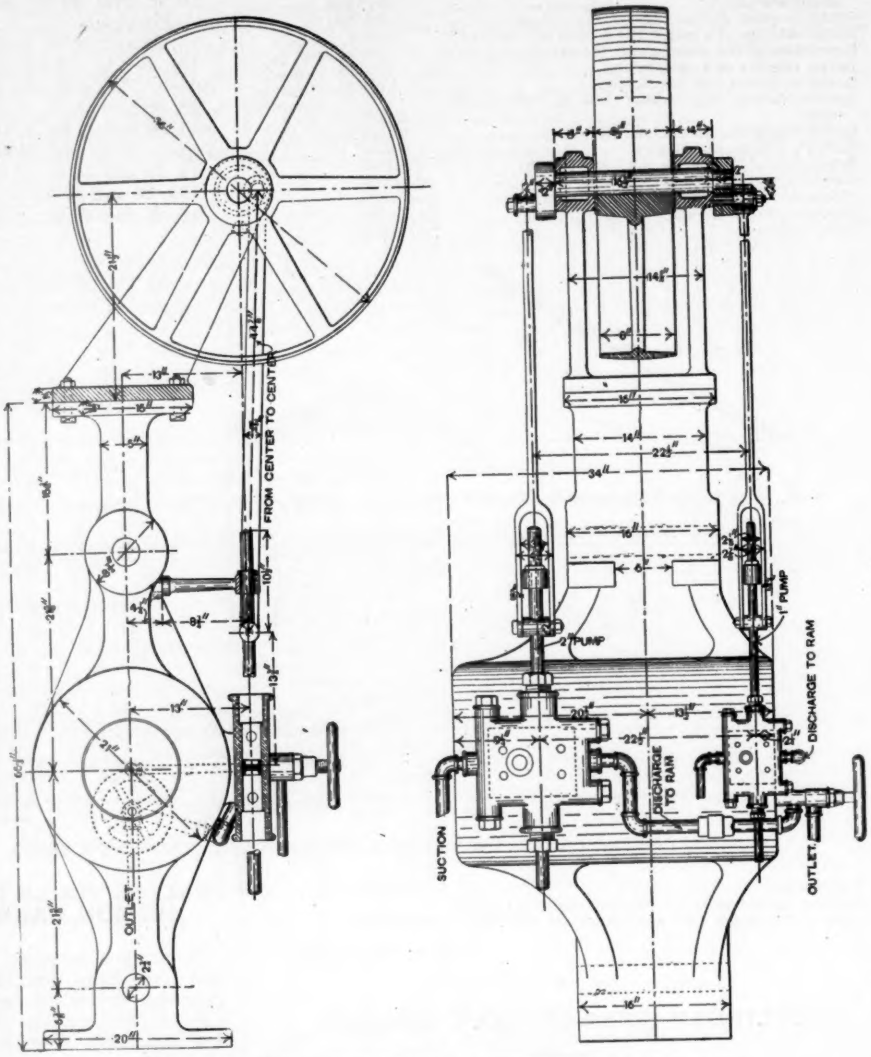
The hoisting is done with a hydraulic cylinder, like all the other work of the same kind in these shops. The engraving shows the upper end of the piston rod. The cylinder is vertical, and has a stroke of 6 ft. with a diameter of 7 in., and works under a pressure of 75 lbs. per square inch.

The barrel rack is shown, and is a simple home-made affair. One of the rods at the bottom is removable. The rack is lowered to the floor, the movable rod taken out, and the barrel rolled into the rack, after which the rod is replaced and the barrel is held firmly in position.

### HYDRAULIC WHEEL PRESS.

In the Green Island shops there is a wheel press that Mr. Cory, the Master Mechanic, says is an example of an evolution. It was originally a screw press, but has been changed from time to time until now it is in the form shown by our engravings. The side and end elevations give a clear idea of the construction of the head and cylinder. The tie rods are 2¾ in. in diameter, and the two pumps have plungers of different diameters, so that the speed can be varied to suit the work in hand. It is possible, however, to run both pumps at a pressure of 40 tons, so that for the ordinary work of pressing on car wheels the full speed can be utilized. It is a big story to tell, but this press has put 52 pairs of wheels on their axles in 65 minutes. It will be seen, from the engraving of the vertical section of the pump, that the plunger is arranged so that it is double-acting, and there is a continuous flow of liquid from the pump to the ram from both pumps. The substantial construction of the machine and the record that it has made certainly is sufficient evidence of its value.

We will continue the illustration of these special tools in our next issue.




HYDRAULIC PRESS, DELAWARE & HUDSON CANAL COMPANY.

## METHODS OF TIN MINING IN THE MALAY PENINSULA.

In a recent report, the United States Consul at Singapore gives an interesting account of the methods of mining pursued by the Malays and Chinese in the extraction of tin from the tin deposits of the Malay Peninsula. It appears from the report that more than one-half the world's tin is mined in the Straits Settlements, the output for the year 1891 being 57,551 tons, against 36,061 tons for the Straits Settlements. If to this 36,061 be added the 12,106 tons, the output of the Netherlands, India, whose tin-bearing islands are within a few hours' steam of Singapore, it leaves but 9,384 tons for the rest of the world.

Up to the introduction of modern tin mining and smelting machinery, in 1889, the tin was worked for a century in a most primitive fashion by the Malays. They simply dug down at the base of a hill, took up the clay which contained the *biji timah* (small nodules), and carefully washed it in running water. When dry it was melted in a furnace built of clay between two layers of charcoal, the fire being forced into a glow by means of bamboo bellows. When the metal became molten it trickled through a hole in the bottom of the furnace into a vessel, from which it was ladled into molds, forming slabs weighing about two catties (2⅔ lbs.). A rajah or chief's wealth was reckoned in bars or slabs of tin.

The primitive tin mining of the Malays gave place to the more energetic and thrifty mining of the Chinese, who brought with them better tools and better business methods. The Chinese monopolized the entire field until the formation of the Jelebu Company in 1889, with which the Chinaman can still compete. The Chinaman's manner of working is simple, though thorough. As the float tin lies at a distance of from 20 ft. to 50 ft. from the surface, gradually diminishing toward the hill sides, where it is not more than 6 ft., the jungle is

cleared along its source, and water is brought by a ditch from the nearest stream. At about 6 ft. down the water begins to rise from the soil, and to get rid of this, and also to utilize the water from the stream as a motive power, an ingenious chain pump is made by constructing a long wooden trough of three planks, each 100 ft. in length, and this is placed with one end resting on the bank, the other sloping to the water in the lowest part of the mine. A wooden chain, with its small oblong pieces of wood placed at right angles to the line, is fitted accurately into the trough. The wooden chain is endless, and is passed round two wheels—a small one at the lower end of the trough, and a large one at the upper end. The latter is a water-wheel, and is turned by a constant stream of flowing water. Round the axle of this wheel are cogs, each of which in turn, as the wheel revolves, draws up a link of the endless chain through the trough, and, as each joint fits accurately into the trough, they bring up in succession a quantity of water, which on reaching the mouth of the trough falls into the channel by which the water which turns the wheel is carried off, and is thus also taken away out of the mine and conducted to the next, when the process is repeated. The small wheel at the lower end of the trough regulates the chain, and guides the wooden joints into the trough.

The Chinaman's tools consist of a hoe, two baskets, and a bamboo pole. The soil is scraped with the hoe into the baskets, which in turn are balanced over his shoulder at the ends of the bamboo pole. The washing is performed in much the same way as placer gold is washed in California and the West. The soil is thrown into a trough filled with running water, in which the dust is carried off in solution and the ore retained by wooden bars nailed across the bottom of the trough.

While the Chinese system of smelting is similar to that of the Malays, it is more elaborate, and carried out on a much larger scale. In place of the bamboo bellows a very ingenious plan is adopted. The trunk of a tree, about 18 in. in diameter and 10 ft. long, is carefully hollowed out and closed at either end. A long pole with a circular piece of wood at one end, fitting exactly into the bore of the tube, acts as a piston. In order to secure the tube being perfectly air-tight, the end of the piston is well padded. Valves are placed at each end, to allow the air to enter, and the center of the nozzle of the bellows communicates with the furnace by a small air passage. On the piston being drawn out, the air in the higher portion of the tube is forced down to the nozzle, and, being drawn back, the air in the further part of the tube is similarly drawn into the furnace. The charcoal is soon brought to a white heat and ready for the molds. The best of the Chinese mines are found in Laroot, in the northern part of Perak, south of the Siamese State of Quebrada, in a stratum of whitish clay. In some of the tin mines in the neighborhood of Batang and Padnay rivers small quantities of gold are found mixed with tin. Consul Wildman says that the Jelebu Tin Mining & Trading Company is the only successful European managed mining adventure in Malays, and one of the chief producers of Straits tin.

## REGULATION OF THE TEMPERATURE OF PASSENGER CARS.

*To the Editor of* The American Engineer and Railroad Journal:

I read with considerable interest your article in the April number on "Comforts of Railroad Travel." The item that interested me most, however, was on the temperatures maintained in cars during the cold weather. Traveling as I do many hundreds of miles during the year, I have experienced all the fluctuations of temperature that a thermometer is capable of, and have often wondered why some automatic regulator has not been put in use that would maintain an even temperature, especially in sleeping cars. Such regulators are in successful operation on furnaces and where steam is used in cities. Cannot they be applied with equal benefit to railroad cars? Perhaps if you ventilated this question fully in your valuable columns it would result in the relief of a suffering traveling public.

Very respectfully yours,

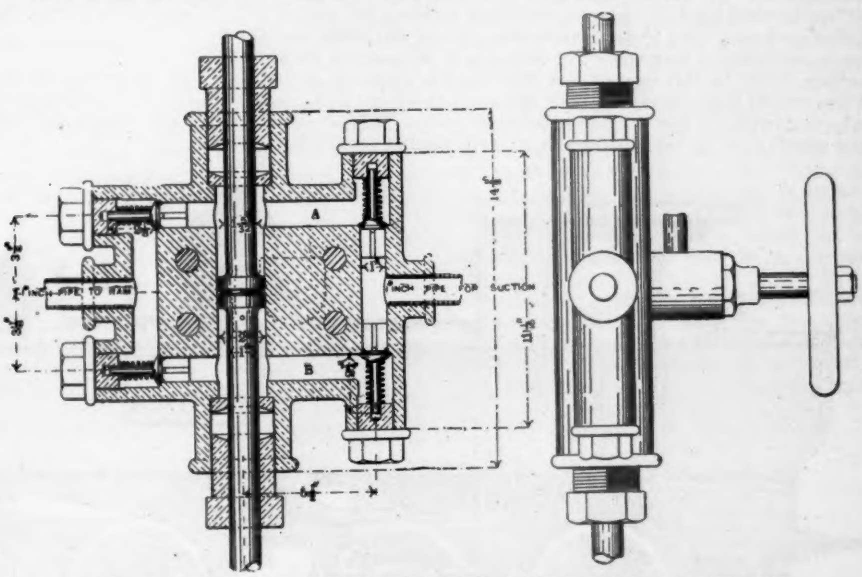
Oliver E. Stanton.

Brooklyn, N. Y.

## MALLET SYSTEM OF DUPLEX COMPOUND LOCOMOTIVES.

By J. A. Maffei.

The duplex compound locomotives, as constructed according to the Mallet system, are composed of two distinct groups of twin steam engines, a high-pressure and a low-pressure one,



PUMP FOR HYDRAULIC PRESS, DELAWARE & HUDSON CANAL COMPANY.

which are both arranged under a common locomotive boiler. The high-pressure engine with its main framing is made in a fixed connection to the boiler, while the low-pressure engine, which is placed at the front end and supplied with exhaust steam from the high-pressure cylinders, is made to swivel under the boiler.

Thus, the high-pressure steam pipes leading from the boiler to the respective cylinders are made a fixture, like in ordinary locomotives, and there is only a movable pipe—forming receiver—connecting the two cylinder systems, also a movable pipe leading from the low-pressure cylinders to the blast pipe.

Unlike ordinary compound engines with uneven cylinders, the duplex compound locomotives, with two pairs of symmetrical cylinders fore and aft, work very steady, with even piston pressures on both sides of the engine, and there are no difficulties at starting.

The engine weight being subdivided over a greater number of axles and a longer flexible wheel-base, there is, besides, less internal engine friction, less straining of the permanent way, this being one of the characteristic advantages of the system. As compared with ordinary engines, the duplex locomotive permits the employment of a lighter rail, or with a rail of a given weight the tractive force may be doubled.

The two steam engines proper are built with outside cylinders and motions and are mounted on an equal number of coupled axles. As the front engine is made to swivel under the boiler, the framing of the locomotive is made of two distinct parts in such a manner that the front framing is coupled or articulated to the hind framing by means of a strong vertical hinge. The hind or main framing, which carries the firebox, is curved upward over the front engine and supports likewise the boiler shell and water tanks, while the framing itself rests by means of suitable slides upon the front engine framing, which is thus enabled to move freely in a horizontal direction. In order to prevent a too great mobility of the front engine a pair of check springs bearing against a support underneath the smoke-box are provided.

The valve motions of both engines are made identically in all their parts. The stationary links are of the "Walschaert" type, and as the volumes of the high- and low-pressure cylinder systems are proportioned for an equal admission of steam, the reversing of the duplex locomotive is effected by a single screw as in ordinary locomotives. The reversing screw acts upon a lever commanding the motions of the hind or high-pressure cylinders; from this lever and by means of an intermediate lever and shaft fixed in the prolonged main framing, also by an articulated tie-rod, the lever commanding the low-pressure cylinder motions is actuated.

At starting the duplex locomotive the boiler steam is admitted to the high-pressure cylinders only; the exhaust steam from these cylinders then fills the receiver, exercising a certain amount of back pressure upon the high-pressure pistons, and actuating at the same time the low-pressure cylinders. The steam pressure in the receiver is limited to 70 lbs. per square inch, there being safety valves provided, which prevent the accumulation of a higher receiver pressure. The boiler pressure amounts from 175 lbs. to 200 lbs., according to circumstances. It should be borne in mind, also, that the receiver forms a kind of pressure regulator between the two cylinder systems; thus, if the front engine should slip there would be immediately a corresponding decrease of pressure in the receiver, while in the case of the hind engine slipping, the reverse would take place. In both cases either engine will cease slipping without the regulator being touched. If necessary, the starting of the locomotive can be facilitated at certain positions of the high-pressure pistons by admitting live boiler steam to the receiver, and this can be done automatically by connecting the auxiliary steam cock with the reversing gear.

The duplex locomotives are fitted with hand brakes in combination with the Westinghouse, or any other system of continuous brake acting upon both engine groups.

As a rule these locomotives are built as tank engines, with total adhesion, the coal bunker being at the rear; but where great provisions of water and coals have to be carried, a separate tender may be added.

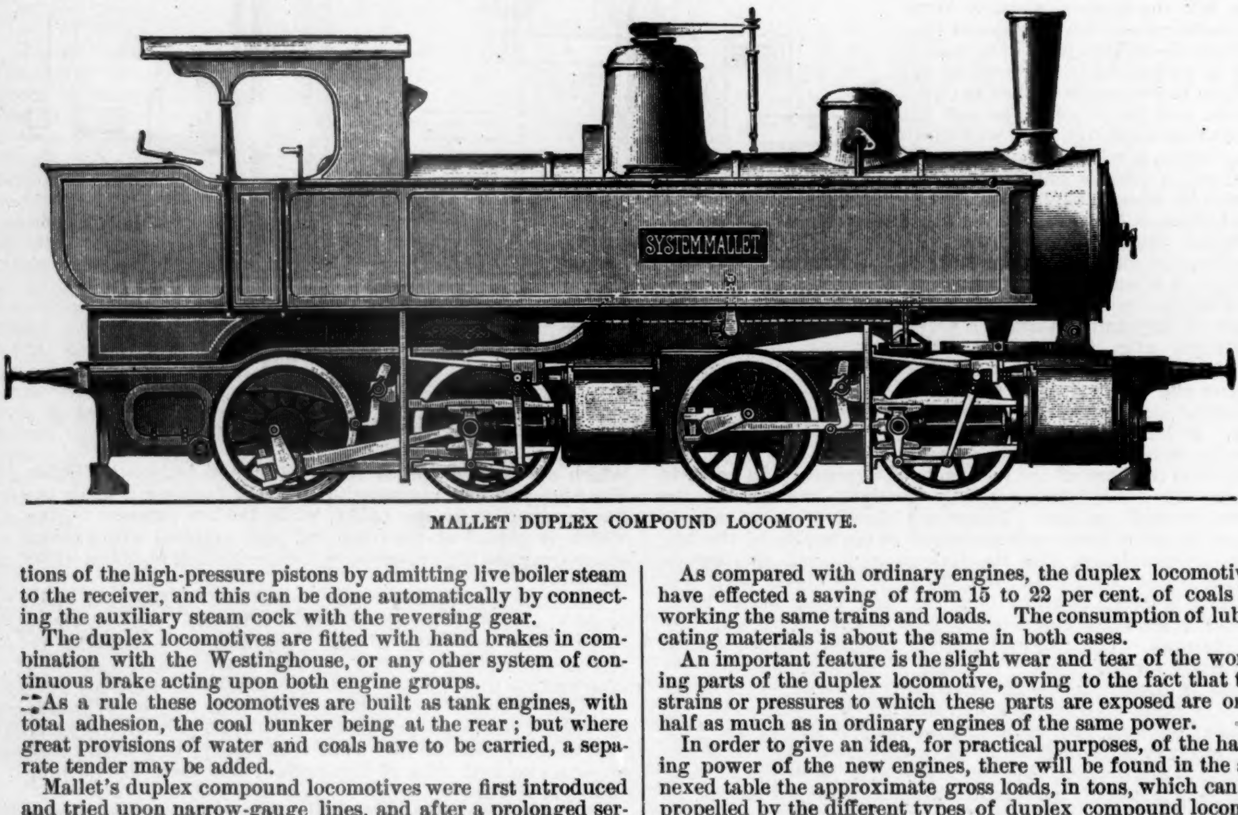
Mallet's duplex compound locomotives were first introduced and tried upon narrow-gauge lines, and after a prolonged service this type of engines proved to be exceedingly well adapted to solve the problem imposed on such motors—viz., "To propel economically, on a rail of given weight, the greatest possible loads over heavy gradients combined with small curves."

Afterward these engines were built for lines of the normal gauge, particularly for mountain railroads, and, as anticipated, the results obtained were highly satisfactory. In the case of heavy trains of any description, the duplex locomotives can be advantageously employed in lieu of the double traction generally made use of.

In the following table are shown the leading proportions of several types of duplex compound locomotives built for various requirements. With the smallest engines of but 12 tons in working order, portable railroads of 2 ft. gauge with rails of 19 lbs. to the yard have been worked; the engines passing freely through curves of 50 ft. radios, and climbing inclines up to 1 in 12. The heaviest engines of 60 and 85 tons weight are employed on mountain railroads in Switzerland—viz., on the Central Swiss and Gothard lines.

| Gauge of Line. | 24 in. | | 30 in. | 1 Meter. | | | Normal. | | |
|---|---|---|---|---|---|---|---|---|---|
| Types Nr. | I | II | III | IV | V | VI | VII | VIII | IX |
| Weight of rail per yard lb. | 19 | 24 | 30 | 36 | 44 | 47 | 50 | 74 | 74 |
| Number of axles per locomotive ........... | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 |
| Load per axle on rails. t | 3 | 4 | 5,5 | 6 | 8 | 10 | 9 | 15 | 14 |
| Weight of engine, empty ...............tons | 9 | 12,5 | 18 | 19 | 26 | 32 | 28 | 44,5 | 67 |
| Weight of engine, full. t | 12 | 16 | 22 | 24,5 | 32 | 40 | 36 | 60 | 85 |
| Total heating surface, sq. ft. | 250 | 310 | 420 | 450 | 720 | 860 | 840 | 1140 | 1670 |
| Grate area.... ...sq. ft. | 5,4 | 6,5 | 8,6 | 9,7 | 11,8 | 15,5 | 16,2 | 18,3 | 23,7 |
| Diameter of wheels..ft. | 2 | 2,4 | 2,6 | 3 | 3,3 | 3,5 | 4 | 4 | 4 |
| Rigid wheel base ....ft. | 2,8 | 3,3 | 3,6 | 3,7 | 4,5 | 5 2 | 4,6 | 5,5 | 8,8 |
| Total wheel base .. ft. | 9 | 11 | 12,3 | 13 | 15 | 17 | 16,5 | 18,3 | 26,6 |
| Radius of smallest curves ..............ft. | 50 | 65 | 80 | 130 | 160 | 200 | 200 | 300 | 400 |
| Tractive force........lb. | 4000 | 5000 | 6600 | 7800 | 10400 | 13200 | 11000 | 15400 | 20000 |
| Boiler pressure......lb. | 175 | 175 | 175 | 175 | 175 | 175 | 175 | 200 | 175 |
| Length of engine with buffers..............ft. | 18 | 20 | 22 | 24 | 29 | 33 | 27 | 34 | 45 |

The above types of duplex compound locomotives have proved very successful in each case, and as a consequence the railroad companies using these engines have repeated their orders.




MALLET DUPLEX COMPOUND LOCOMOTIVE.

As compared with ordinary engines, the duplex locomotives have effected a saving of from 15 to 22 per cent. of coals by working the same trains and loads. The consumption of lubricating materials is about the same in both cases.

An important feature is the slight wear and tear of the working parts of the duplex locomotive, owing to the fact that the strains or pressures to which these parts are exposed are only half as much as in ordinary engines of the same power.

In order to give an idea, for practical purposes, of the hauling power of the new engines, there will be found in the annexed table the approximate gross loads, in tons, which can be propelled by the different types of duplex compound locomotives. The resistances have been computed at 11 lbs. per ton at a mean speed of 15 miles per hour. The loads are given exclusive of engine weight.

| Types Nr. | | I | II | III | IV | V | VI | VII | VIII | IX |
|---|---|---|---|---|---|---|---|---|---|---|
| Tractive force lb. | | 4000 | 5000 | 6600 | 7800 | 10400 | 13200 | 11000 | 15400 | 20000 |
| Gross load hauled in tons on inclines of: | 0 | 350 | 440 | 580 | 670 | 900 | 1100 | 960 | 1300 | 1700 |
| | 1 : 200 | 170 | 200 | 280 | 320 | 440 | 550 | 460 | 600 | 800 |
| | 1 : 100 | 110 | 140 | 180 | 210 | 280 | 350 | 300 | 400 | 500 |
| | 1 : 66 | 80 | 100 | 130 | 150 | 200 | 260 | 210 | 300 | 370 |
| | 1 : 50 | 60 | 80 | 100 | 110 | 150 | 180 | 160 | 220 | 280 |
| | 1 : 40 | 50 | 60 | 80 | 90 | 120 | 150 | 125 | 160 | 220 |
| | 1 : 33 | 40 | 50 | 65 | 70 | 100 | 120 | 105 | 140 | 170 |
| | 1 : 28 | 35 | 45 | 55 | 60 | 90 | 100 | 92 | 110 | 140 |
| | 1 : 25 | 30 | 35 | 45 | 50 | 75 | 90 | 76 | 90 | 120 |
| | 1 : 22 | 25 | 30 | 40 | 45 | 65 | 70 | 66 | 80 | 100 |
| | 1 : 20 | 20 | 25 | 30 | 40 | 55 | 60 | 56 | 70 | 85 |

## THE ERICSSON SUBMARINE GUN.

(From *Annual No. XI.* of the Office of Naval Intelligence.)

THE Ericsson gun and projectile, as fitted on board of the *Destroyer*, are shown in the drawings, ready for firing.

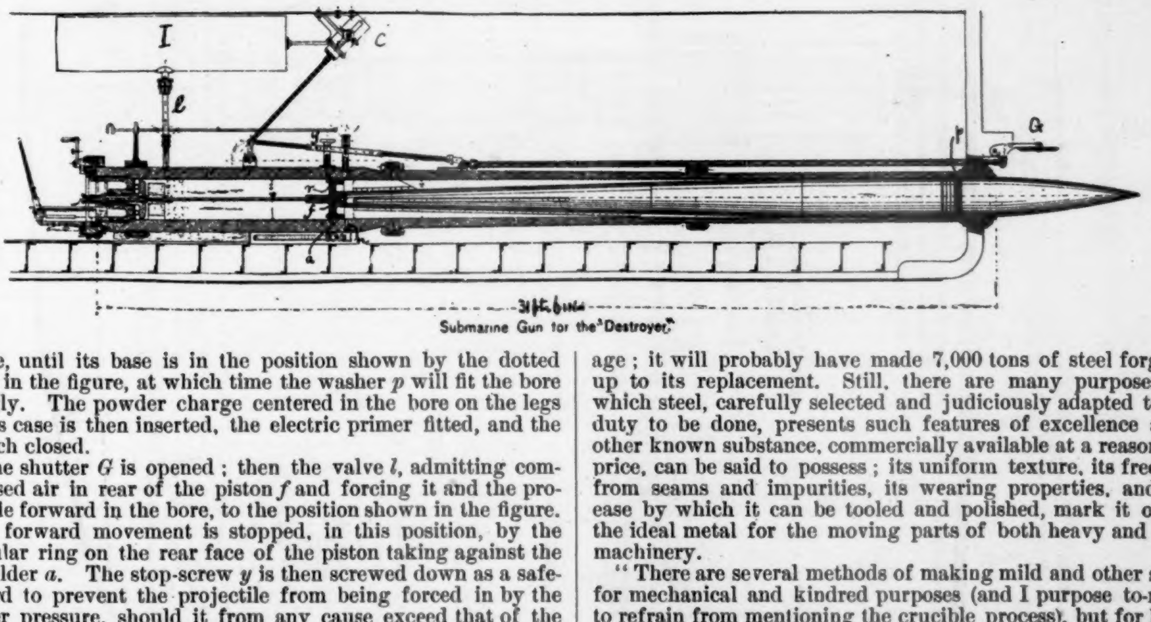
The weight of projectile is 1,525 lbs.; length, 27 ft. 4 in.; diameter, 16 in.; explosive charge, 300 lbs.; propelling charge, 40 lbs. The initial pressure calculated is 4,000 lbs.; mean pressure, 1,692 lbs.; muzzle pressure, 895 lbs.; and the muzzle velocity, 548 ft.

The gun is fitted with a slotted-screw breech mechanism. The diameter of the bore is 16 in., and the chamber is enlarged, there being a decided shoulder at *a*. The bow shutter *G* is controlled by a rod actuated by the compressed air cylinder and piston *C*. The drain-pipe *n* is controlled by a valve; *I* is the compressed air cylinder connected to the gun chamber by the valve and pipe *l*, and *y* is a set screw stop.

The projectile is made in three sections, for convenience in handling and stowing, which are connected up before loading. It is fitted near the head with a leather grommet, *p*, and has horizontal and vertical tail fins.

The piston-head *f* has a hollow stem screwed into it which, is slightly longer than the propelling charge, and is provided with spring packing rings which cause it to fit neatly during its passage through the bore or the chamber. It has a center recess in its front face, is seated the tail end of the projectile, to which it is secured by a set screw. On its rear face is a soft metal annular ring of such diameter that it admits of passage through the enlarged chamber, but is greater than the diameter of the bore.

The working of the gun is as follows: The bow shutter *G* being closed, and the water drained out of the gun through *n*, the breech is opened and the projectile, on a carriage in line with the gun, is run into the bore until the tail just projects to the rear. A piston-head is then fitted to its tail, and the set screw is tightened sufficiently to keep it from turning, but loose enough to allow it to slide off when it meets the resistance of the water. The projectile is then shoved further home, until its base is in the position shown by the dotted lines in the figure, at which time the washer *p* will fit the bore snugly. The powder charge centered in the bore on the legs of its case is then inserted, the electric primer fitted, and the breech closed.



Submarine Gun for the "Destroyer."

The shutter *G* is opened; then the valve *l*, admitting compressed air in rear of the piston *f* and forcing it and the projectile forward in the bore, to the position shown in the figure. The forward movement is stopped, in this position, by the annular ring on the rear face of the piston taking against the shoulder *a*. The stop-screw *y* is then screwed down as a safeguard to prevent the projectile from being forced in by the water pressure, should it from any cause exceed that of the air pressure.

The valves *n* and *l* are then closed and the gun fired. The pressure of the powder gas causes the annular base ring of the piston to curl back when forced against the shoulder *a*, and thus cupped it allows of forward movement, at the same time acting as an additional gas-check. Upon entering the water the piston-head falls off, free from the projectile. The shutter *G* is then closed, the drain-cock *n* opened, and, when freed of water, the gun is ready for another charge.

Experimental firings have lately been conducted by the Torpedo Board with the gun fitted to the *Destroyer*.

The boat was moored 100 ft. from the dry dock, in which were suspended six nets 40 ft. long by 20 ft. deep, each 100 ft. apart, their centers being in the center line of the dock. Firing thus into the dock insured the recovery of the projectiles to facilitate investigations as to the causes of possible erratic shots.

Twenty shots have thus far been fired, one of which was with a special automatic projectile. The firing charges employed have not exceeded 30 lbs., although the gun is designed to withstand charges of 40 lbs.

From the results thus far attained it is safe to say that the experiments have demonstrated the possibility of firing a submarine projectile 600 ft. by powder discharge; that up to that range the vertical danger space is from the surface to a depth of 22 ft., and the lateral accuracy sufficient to strike a vessel 50 ft. long.

The explosion of such a charge of high explosive, even at the water-line of a vessel, if not proving fatal would certainly do very great damage.

## THE SELECTION AND TREATMENT OF STEEL FOR FORGINGS.

AT a recent meeting of the Leeds Association of Engineers Mr. Francis Rixon, of Sheffield, read a paper upon the above subject from which we extract as follows:

"Before the invention of the Bessemer process of making steel, and for some time after, until confidence in that material was established, fagoted iron was the only material available for engine and machine forgings, and notwithstanding its tendency to establish seams, and evident laminations, it served its purpose admirably, and even now, in the presence of mild steels of the highest excellence, an excellence far beyond the hopes of their several inventors, it continues to hold its own. For all difficult shapes where steel castings are not permissible, and where piecing up after partial machining is necessary, and, further, where 'case-hardening' is called for, a good iron is essential, and will hold the field in its proper sphere.

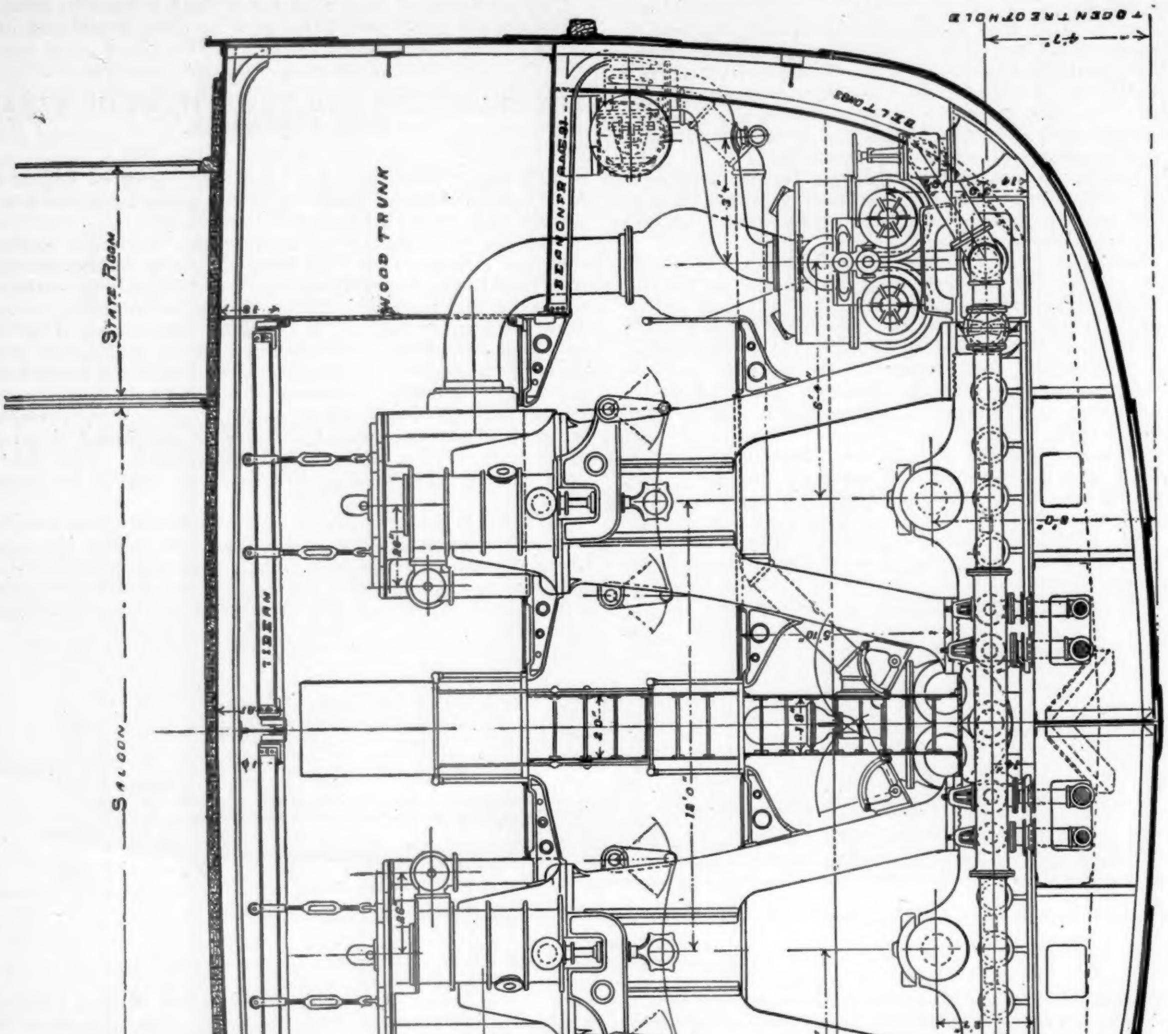
"Then, for the screw shafts of steamers and piston-rods for steam-hammers, iron lasts longer than steel, unless the latter are oil-tempered before using. An iron rod in one of our hammers was in constant use over 13 years, and is now good, but kept as a duplicate. I never heard of a steel rod half that age; it will probably have made 7,000 tons of steel forgings up to its replacement. Still, there are many purposes for which steel, carefully selected and judiciously adapted to the duty to be done, presents such features of excellence as no other known substance, commercially available at a reasonable price, can be said to possess; its uniform texture, its freedom from seams and impurities, its wearing properties, and the ease by which it can be tooled and polished, mark it out as the ideal metal for the moving parts of both heavy and light machinery.

"There are several methods of making mild and other steels for mechanical and kindred purposes (and I purpose to-night to refrain from mentioning the crucible process), but for high-class work engineers and technical experts generally agree that the Siemens process is the one most reliable; its earlier sister process, the Bessemer method, to which the world owes much, not only to Sir Henry Bessemer, but also to Mushet, whose spiegeleisen made the blown, or decarbonized, metal malleable, but also to Heath and other workers, whose names do not often appear in the light they deserve. Where quantity is the first consideration, the Bessemer process is vastly superior, but where nice gradations of temper and quality are imperative, the Siemens is indispensable, as frequent tests can be taken and variations made in the composition, until the exact point is reached which the specification being worked to calls for. There is also the more recently developed basic process both in Siemens and Bessemer practice, but as those yield a class of material for constructive and commoner purposes, they do not fall within the scope of these remarks.

"The steel best adapted for forgings, such as piston-rods

of engines, main engine shafts, marine cranks, and other parts subject to severe torsional strains and carrying heavy loads, should be of such a nature as to give a tensile stress of 27 to 30 tons per square inch, with a high percentage of elongation, say 35 per cent. in 2 in., and a reduction of area of, say, 45 to 55 per cent. A bending test 1 in. square, 10 in. long, should bear bending over a round bar 1½ in. diameter and it should bear closing thus ⊂ and show no sign of fracture. For special cranks for high-speed engines a steel of higher tensile strength is desirable, and 34 tons tensile, 28 per cent. elongation, and from blemishes than the softer grades of material. Perhaps the best proof of this is to be found in the punishment or fatigue test, described at the end of this paper—a test which leaves no doubt of the capacity of the material to resist such shocks as may be expected in use.

"The falling test is one on which public engineers rely almost as much as on the tensile test. Select a forged steel bar, say 3½ in. diameter and 5 ft. long, place it on supports 3 ft. apart, drop a tup of 1,120 lbs. on it from a height of 20 ft., continue the blows until an angle of 90° is reached,




SECTION THROUGH ENGINE ROOM OF STEAMER "VIRGINIA."

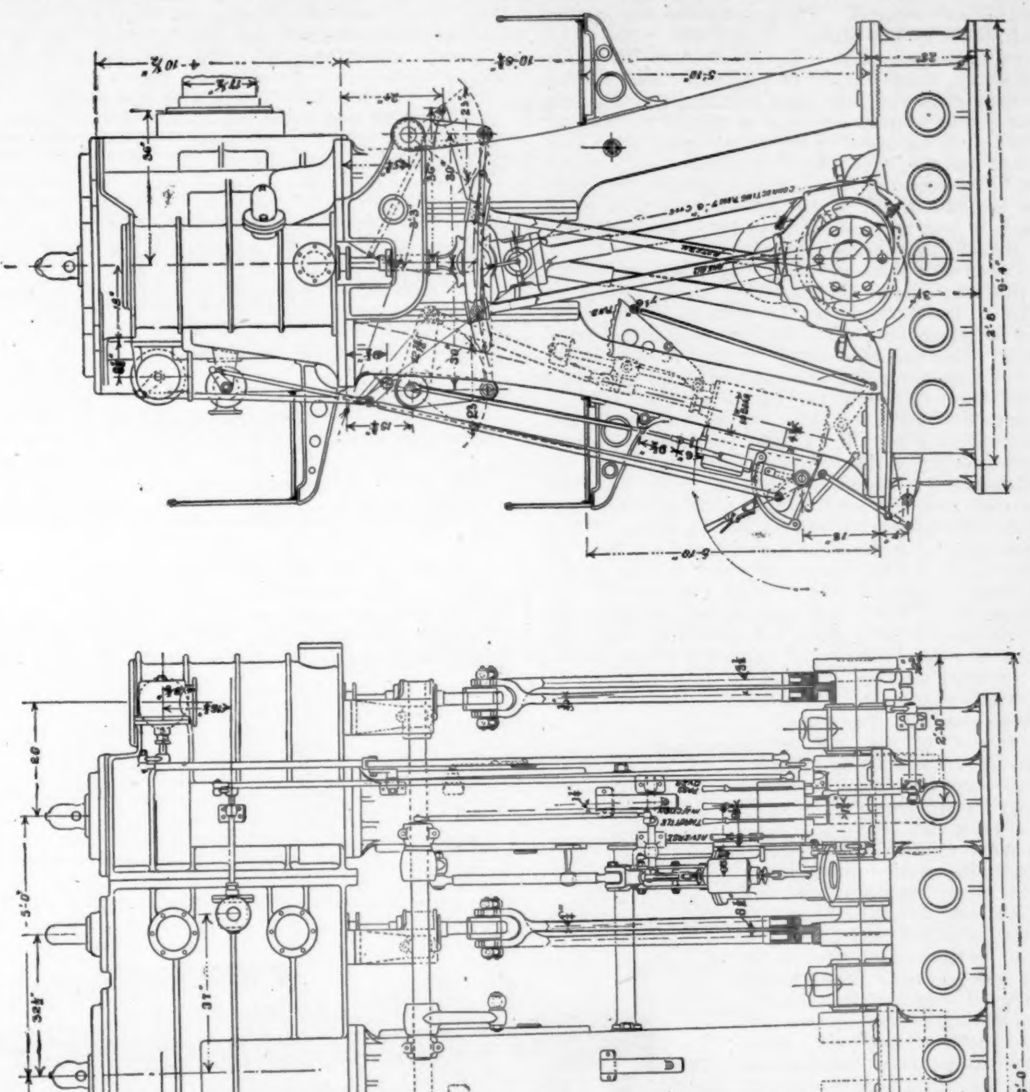
52 per cent. reduction gives excellent results, especially when used in white metal bearings; it never licks up the metal.

"It is not necessary to define the chemical composition of an ideal forge steel, as good results can be, and are, produced by different methods; but I prefer a stiff steel of good quality to a soft steel of low character, and I always question the judgment of engineers who stipulate that their forgings should be made of steel under .15 carbon. My own opinion is that about .30 is better in every way, and is certainly more free then press the ends toward each other until this curve is reached ⊂ without fracture. A railway axle of the usual shape, 4½ in. diameter in the middle, bore six blows of 20 ft. each, from a tup 1,650 lbs., without breaking; and a further blow of 38 ft. broke it. Another axle, 4½ in. diameter, bore six blows of 20 ft. and 11 blows of 40 ft. without breaking; after this seventeenth blow (it being warm from concussion) it was cooled in ice and snow, and broke at the eighteenth blow—and no wonder. An iron axle was next tested, 4⅝ in.

diameter. The test specified was six blows from 25 ft. It broke at the fourth blow, showing a coarse, dirty fracture. A steel axle, same size, bore six blows of 25 ft., and also 20 blows of 40 ft. These particulars show the wonderful tenacity of a good steel forging, and when it is remembered that good steel is cheaper than good iron, the difference in strength, as an equivalent of money, is the more remarkable.

new iron. Before leaving the question of material, I may say that Siemens steel is now being made from .09 carbon up to 1.50 per cent. The latter is used for fine files with great success, while tempers of .75 to .95 make wonderfully good saws and springs; indeed, so successful has this become, that common crucible steel is a thing of the past.

"And now, having described the nature and quality of the



PORT ENGINE OF GOODRICH LINE STEAMER "VIRGINIA."

"As a result of excessive vibration, iron and steel are liable to 'tire,' and become flaky or granular; and the late Mr. Robert Hadfield once showed me a bar of iron which had been subject to some thousands of sharp blows—a piece was easily broken from the $1\frac{1}{2}$ in. round bar by a hand hammer. The flakes were something like the scales of a roach. The other piece of the bar had been re-heated and thrown down to cool, and its fracture was fibrous, like an ordinary piece of

material for forgings, a word as to treatment. Much depends upon the manner in which the heating or furnacing is carried on. The heating should never be rapid; time should always be given for thorough soaking through, or wasters are a certainty; and you all know how disappointing it is, sometimes disastrous, to find days and sometimes weeks of turning are lost by a flaw appearing just when the job is apparently done. Hammering should never be too rash at first; it segregates the

particles and weakens the piece. On the other hand, cold hammering is objectionable, as tending to brittleness. Steel so treated needs to be, and ought to be, annealed as also should all forgings made in bosses or dies to exact shapes, else, when at work, they are liable to expand and fret their bearings.

"There is another method of making forgings, which has budded and faded more than once, to which reference may be made—viz., the use of piled scrap steel, which is fagoted into blooms, re-heated and swaged. The process was first applied at Dumbarton, later by the Mersey Forge, who rolled down ingots into flat slabs, and piled and welded them for cranks and other important work. Railway companies also use this plan for side-rods, draw-bars, etc.; the resulting forgings ring under a stroke of a hand hammer, same as steel, but a fracture looks like iron. I do not approve the use of this process generally, believing the forgings would be affected by extreme frost, and be, in consequence, dangerous, especially for draw-bar hooks, on account of the sharp snatches they have to endure. I think it best to pass the steel plate scrap through the Siemens furnace, and use new ingots.

"In connection with this subject, I may allude to the importance of the drop stamp for producing small forgings in large quantities. The saving over hand-made articles is remarkable, but not more remarkable than the greater excellence of the product. The principal factor in this process is the dies, which must be made of very good material and exact workmanship. The next point to observe is the selection of a good soft material, which will bear forcing into the desired form, without breaking up; and a most important feature is that the guides are true, or the trimming after the stamp will be very troublesome. It sometimes happens in the manufacture of important steel forgings that, in spite of great care, internal defects will exist in the interior of the piece. These defects are generally to be traced to the existence of gas or air bubbles in the ingot, which hammering and rolling do not remove, but usually aggravate, by driving the occluded gas in various directions. Now, this subject has occupied the minds of several good metallurgists, but the remedy is, in the main, as far off as ever. Whitworth employed the hydraulic pressure on the fluid steel as a remedy, but it is extremely expensive in practice, and has not been generally followed.

"Another branch of the business of forging is that known as bending prepared bars of forged steel or iron into bent cranks by using the hydraulic press. It means a great saving of time and labor, and when numbers of a given type and size are called for, and a powerful steam stamp associated with the press, cranks of the best shape and finish can be produced at very low prices, the principal outlet being in the direction of portable and kindred engines and for gas engines. This process was first employed only for the manufacture of cranks having a sound section, but since 1884 the firm of which I am a member turned their attention to making bent cranks, having the same configuration as forged slab cranks, at the same time providing for the fiber of the material to be continuous throughout the piece, and at the same time to avoid the delay and labor inseparable from the drilling and slotting of slab cranks. This process is now in daily operation for locomotive and electric-lighting engines, and also for marine and mill engines, and is giving great satisfaction.

"It may be said that wonderful mileage has been got out of locomotive axles by the older method; indeed, recent cases have come under my observation showing 750,000 miles run; but it is very frequently the case that new axles go in their first year, and in many cases the causes are due to want of work on the vital parts. Numerous 'cripples' recently examined show fractures on the underside of the crank-pin, the next in order show weakness on the inside web, and others fail from the strain of twisting by wrenching the webs from a straight line to right angles at the forge. I ought to speak cautiously at Leeds on this subject, but I am convinced that the present practice of locomotive crank-axle making is wasteful, clumsy, and expensive, giving the worst results at the maximum expense.

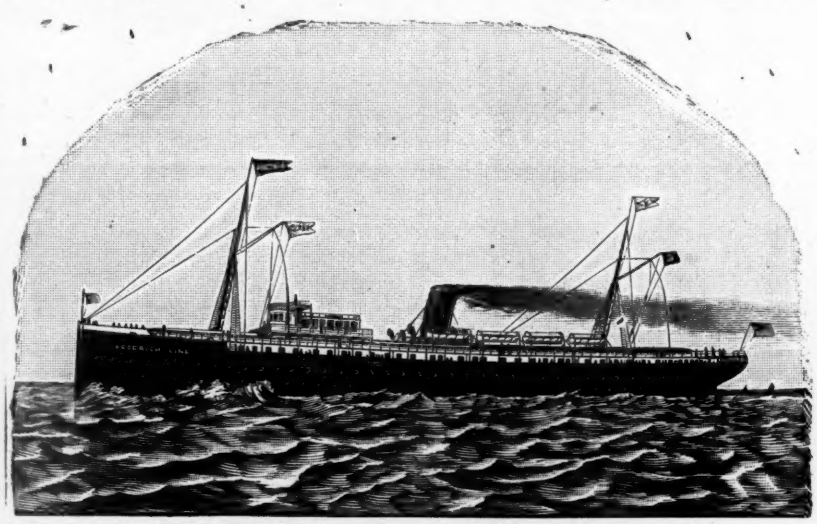
"Intimately connected with steel forgings is the practice of tempering in oil, in order to increase the toughness of the article so treated. Locomotive axles are often oil-tempered, as are the inner tubes and trunnions of large guns, while smaller guns are heated entire and quenched vertically in a bath of oil, the oil vat being itself immersed in cold water, sometimes artificially cooled, so as to keep the oil at proper temperature. Steel, which in its normal state will bear a maximum load of 31 tons, will, after heating and quenching in oil, carry 43 tons tensile, and gun barrels after such treatment are re-heated sufficiently to reduce the tensile to 37 tons, which gives excellent practical results. In this state the metal works very sweetly. I recently saw a turning, 268 ft. long, taken from an oil-tempered steel gun barrel. Where high results are desired, and price no object, the oil tempering is a very good thing, but, like other good things, it costs money.

FATIGUE TESTS ON CRANK STEEL.

A piece of the steel planed out of the solid, 1¼ in. square, and 12 in. long, is placed upon supports 6 in. apart, and a tup weighing 1,120 lbs. is dropped from a height of one foot upon the specimen, and the piece turned over after each blow.

| Mark on Specimen. | Description of Material. | Maxim. Tensile per Square Inch. | Elongation Per Cent in two Inches. | Reduction of Area Per Cent. | No. of Blows before Distress. | Total No. of Blows. | Remarks. |
|---|---|---|---|---|---|---|---|
| 25 | Ordinary forging steel | 29.0 | 35.22 | 53 50 | 23 | 25 | Deflected freely under drop. |
| 45 | Admiralty crank steel | 27.3 | 31.50 | 52.40 | 39 | 45 | Deflected freely under drop. |
| 57 | Fluid compressed steel | 33.65 | 31.00 | 58.50 | 49 | 57 | Deflected freely under drop. |
| 78 | Special W. & R. crank steel. .. | 34.00 | 33.00 | 56 80 | 73 | 78 | Deflection much less than the others. |

"Another subject in connection with forgings is that of the proper allowance for tooling. This is a question on which all the doctors differ, and can best be solved by the application of a little common sense. Engineers will ask for three-sixteenths on a double crank, and others will allow half an inch



STEAMER "VIRGINIA" OF THE GOODRICH LINE.

on a plain bar of similar size. Both are wrong; a very good rule for articles having but one setting is to allow ¼ in. up to 5 in. diameter, ⅜ for 6 in., 7 in. and 8 in., ½ in. for 10 in., and 1 in. for 1 ft. Most turners will agree that an allowance sufficient to clean up the forging all over is more easily dealt with than a closely forged shaft, which has to be humored in the lathe, and requiring its centers altering several times. Given a good lathe, a good man, and a straight forging, no one need complain if an extra eighth has been left on by the forgeman."

## THE TWIN SCREW STEAMER "VIRGINIA."

THE illustrations on pages 228 to 230 give a very good idea of the general external appearance of the twin screw steamer *Virginia* of the Goodrich line, together with the method of construction both of the hull and the engines. The dimensions of the vessel are: Length over all, 277 ft.; length of keel, 264 ft.; beam, 38 ft.; molded depth, 25 ft. She was built by the Globe Iron Works Company, of Cleveland, O., in

1892. Electric lighting on the Mather system is used throughout. There are two Mather compound wound dynamos, ring type, with a capacity of 400 lights each. The switch-board is fitted up with magnetic vane ampère meters and volt meters, circuit distributing blocks on slate bases. The circuits are so arranged that the lighting in different parts of the ship can be controlled on the switch-board, special circuits being run for night and day service. All chandeliers, ceiling lights, and side lights are controlled by switches and all circuits are alternated, so that one-half of the lamps or the whole can be lighted, and in case a fuse should blow out in a circuit the other half of the lamps will remain lighted. The loss on the circuit is less than 2 per cent., and the insulation resistance, with fixtures, dynamos, sockets, lamps, and everything connected, is over 270,000 ohms. A powerful search-light is located on the foremast.

The engines, one of which we illustrate by a full-page engraving, are of the triple expansion type, with cylinders 20, 32, and 52 in. diameter by 32 in. stroke. There are two double-ended boilers 13 ft. in diameter by 22 ft. in length, which are allowed by the Government inspection to carry steam at 160 lbs. pressure. They are equipped with 12 furnaces, each 40 in. in diameter. The fire-hold is air-tight and is supplied with two fans for a forced draft having a capacity of 30,000 cub. ft. of air per minute.

The hull is built entirely of steel, and the lines are so molded that with ordinary weather and a forced draft 22 miles per hour is obtained, while 20 miles per hour is run with the natural draft.

## MECHANICAL FLIGHT.

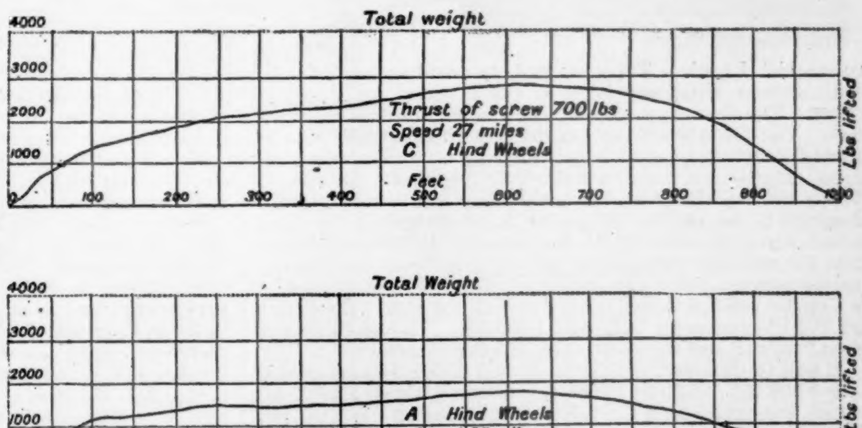
By Hiram S. Maxim.

I notice in a contemporary scientific journal an article entitled "Mechanical Flight," in which certain very interesting experiments which are being tried at Harrow by Mr. Phillips are described, and in which also some allusions are made to myself and my experiments. About two years ago in some articles which I wrote for the magazines, I pointed out that when flying machines were made successful their first great use would be for military purposes, that they would be employed for carrying high explosives and for dropping them into the enemy's lines and country, and that if the French were the first in the field it would be for them a machine for the rectification of the map of Europe. Ever since that time the newspapers of the whole world have been describing me as wishing to drop dynamite into English towns, and in a late article, St. Paul's and Woolwich Arsenal are suggested as points of attack. I am not so bloodthirsty as I am represented to be, and I have no personal designs against any country that I know of; but I do not believe that the millennium is at hand, or that the time has yet arrived when wars may be considered as completely at an end. The Russians believe that the time is not far distant when they will dominate the whole of Europe and a large part of Asia, while the Americans are firm believers in "manifest destiny," the doctrine which is so beautifully set forth in the spread-eagle Fourth of July orations. It means America for the Americans, in fact, the whole continent and all the adjacent islands. Of course these changes cannot be brought about, or, indeed, attempted without war; and if we are to have war and the flying machine is to become a reality, I feel convinced that it cannot fail to be the principal engine of destruction in the future. Up to four years ago I do not believe that any aeroplane had ever been made to lift more than two or three ounces. Thomas Edison is said to have tried the experiment of lifting with a screw, but only succeeded in raising 4 lbs. with a 1-horse motor. Three years ago Professor Langley tried a remarkable series of experiments with the aeroplane and screw propulsion, and although the load which he carried only amounted to a few pounds, he carried at the rate of 250 lbs. to the H.P. Three years ago I also tried a series of experiments with a very perfect apparatus, provided with all sorts of dynamometers, tachometers, and measuring apparatus. In these experiments I carried 133 lbs. to the H.P., though in some cases, with a high velocity and a plane set at a low angle, I approached very nearly to Langley's figures.

According to the article referred to, Mr. Phillips has been at work 27 years on flying machines, and it is claimed that he has actually succeeded in lifting about 400 lbs. practically clear of the ground, but no mention is made of how much power was consumed in accomplishing this. It is also stated that he succeeded in raising "very nearly 3 lbs. per square foot of wing surface, which we imagine is far beyond any result yet obtained."

From the article it would appear that Mr. Phillips is not a believer in the aeroplane system. I am quite willing to admit that, everything else being equal, a greater amount of lift in proportion to the area of the planes and the power consumed may be obtained with a large number of superposed planes than when the same amount of surface is all in one plane, approximately square in shape: but small planes one placed above the other would not afford protection against a very rapid descent in case of breakage of the machinery. Moreover, a properly constructed aeroplane may be made to lift considerably more than 3 lbs. per square foot. In my first experiments I succeeded in carrying 8 lbs. per square foot of aeroplane, the planes being 13 in. wide and 6 ft. long.

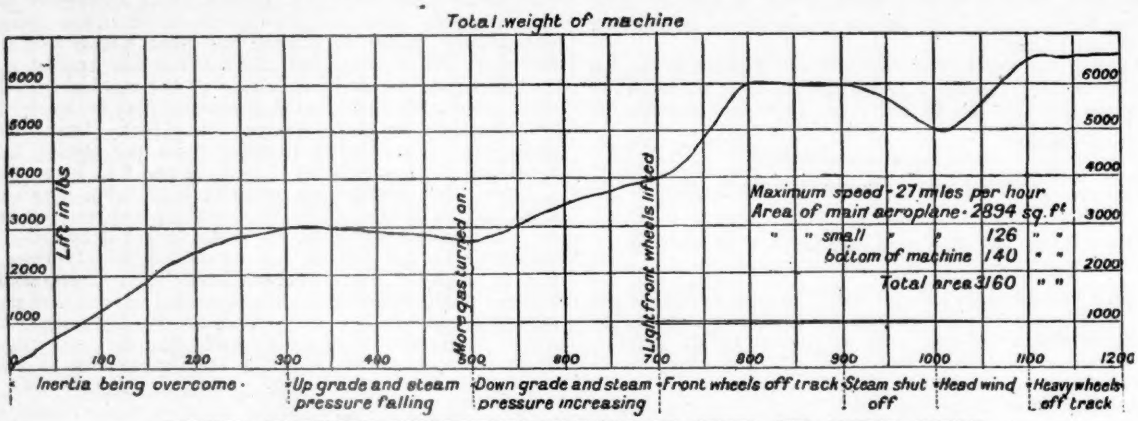
Again, "Mr. Phillips has found that anything approaching a flat surface is useless for supporting heavy weights in the air. In small experiments, where the weight to be raised only amounts to a few ounces, and where a relatively large area may be employed, surfaces approximately flat may be secured; but in a flying machine capable of raising hundreds of pounds instead of ounces, it is impossible, Mr. Phillips maintains, to secure plain surfaces for sustainers having the proportion of 1 sq. ft. for each pound raised." It is quite true that a flat aeroplane is not the best that may be employed; mine are all slightly curved. But Mr. Phillips is mistaken if he thinks that large weights cannot be raised by properly constructed aeroplanes, as the following will show. In my experiments




LIFTING POWER AND SPEED—MAXIM'S AEROPLANE

with the whirling table traveling round a circle 200 ft. in circumference, I found that a wooden plane would easily carry more than 100 lbs. to the H.P., but when I came to stretch textile fabric on a frame, I found that I could not carry more than 40 lbs. to the H.P. Professor Langley admitted to me that he was able to carry a great deal more with flat wooden or metallic planes than he ever succeeded in carrying with paper covered frames This seemed to point to the fact that there was a great deal of drag and waste of power unless the planes were sufficiently rigid to preserve their shape perfectly.

Having finished my whirling table experiments, I commenced on a larger scale, and provided myself with a railway track about 9 ft. gauge and 1,800 ft. long. My machine is of great size, the total weight being about 7,000 lbs. The engines have already developed 300 brake H.P. Two screw propellers are used, each 17 ft. 10 in. in diameter. In my first experiments with this large machine, I found that there was a great consumption of power that did not manifest itself in lift. In order to ascertain what became of the power, I provided myself with dynamometers, tachometers, and dynagraphs, and all the necessary apparatus for ascertaining to a great degree of nicety all the events that were taking place during the short end of the run, not only were the light wheels, the forward end of the machine and the men lifted from the track, but the heavy wheels were also raised, and when the machine came to a state of rest, one wheel sank deeply into the soft ground, and a sudden squall coming up, the machine was tipped over on its side. My overzealous assistants, whose number had suddenly increased to more than 40, commenced at once to pull at the wires, and were not satisfied until they had broken the framework on which the aeroplane was stretched. The diagram *E* shows the total lift on both the forward and hind axletrees during this run. It will be observed that when the machine had traveled 800 ft. the total lift was 6,000 lbs. This was due altogether to the push of the screws. It afterward mounted to 6,500 lbs., but this was due to a head wind. The maximum speed when the diagrams *A* and *B* were made was at the rate of 25 miles an hour; with all the other runs, the speed was at the rate of 27 miles an hour. The machine is provided with a very delicate and accurate apparatus, which shows on a very large indicator the exact speed at which the machine is traveling through the air. During all these runs the principal lift was obtained from a large aeroplane of 2,894 sq. ft. The total width of the aeroplane is 50 ft., and the




MAXIM'S AEROPLANE EXPERIMENTS—DIAGRAMS OF SPEED AND LIFTING POWER

runs which I made. The machine is mounted on four wheels, with springs interposed between the axletrees and the machine. The dynagraphs are attached to the center of the axletree. The drum which carries the paper turns once round in 1,800 ft., and the pencil traces a line on the paper which indicates exactly how much weight is resting upon the wheels. When the machine lifts, the pencil rises, and a very graphic diagram is the result. Diagrams *A* and *B* represent the run which was made about three months ago. Before making the run, the machine was attached to a dynamometer, the throttle-valves between boiler and engine fully opened, and the gas by which the boiler is heated turned on until the pull of the screws on the dynamometer indicated 1,000 lbs. The machine was then "let go" and the steam shut off after running 800 ft.

It will be observed that the maximum lift on the hind wheels was 1,900 lbs., and the lift on the forward wheels 2,300 lbs., which was very nearly the full weight resting on these wheels. But this was not as much as it should have been. Certain alterations were then made in the aeroplane, and the next run was made on the 16th day of February. The machine was attached to the dynamometer as before, and was "let go" at 700 lbs. Thinking that perhaps the lift might be too great, three men and other weight—500 lbs.—were put on to the machine directly over the forward axletree. Diagrams *C* and *D* represent the result of this run. It will be observed that the lift on the hind wheels was increased nearly a thousand pounds, while the lift on the forward wheels was but slightly increased; still if the men had not been put over the front axletree the forward wheels would have lifted from the track. Wishing to make another run with 1,000 lbs. pull on the dynamometer, I attached a pair of additional wheels under the front end of the machine, connected in such a manner that the small and lighter wheels could lift 3 in. from the track and still leave the heavy wheels on the track. Three men were also placed over the forward axletree, and a run was made with 900 lbs. pull on the dynamometer. After the machine had run about 400 ft., the light wheels lifted clear of the track, and when the engines were stopped they came back again on to the track all right. The machine was then run again with 1,000 lbs. pull on the dynamometer. After the machine had run about 300 ft., I noticed that the steam pressure was falling, and I turned on a little more gas, perhaps a little too much. The result was that the speed increased considerably, and at the greatest thrust of the screws at the time of starting was 1,000 lbs. The runs were made with four men, 600 lbs. to 800 lbs. of water, and 200 lbs. of gasoline on board. The total width of the machine when all the aeroplanes are in position is 100 ft. About half of the planes were in position, and the engines were run at about half of their power. The thrust of the screws when the engines are run at full power is 1,960 lbs.

From the foregoing it will be seen that there is no question about an aeroplane being made to lift heavy loads, and where others—except Mr. Phillips—have lifted ounces, I have lifted tons. These measurements have been made with great care, very perfect and accurate apparatus has been employed, and as far as I am able to judge, they are thoroughly reliable. I do not see where any error could have crept in. So far as propulsion and lifting power are concerned, I think we may assume that the flying machine is a *fait accompli.* Difficult problems are no doubt still before us, but I think if I had one of the large American prairies in England to manœver and experiment on, that the whole question might be solved inside of a year.—*The Engineer.*

## LAMINATION IN METAL.

Professor John Tyndall contributes something new upon the subject of cleavage as it occurs in crystals, rocks, ice and other bodies; and his studies lead inevitably to the conclusion that lamination results from the operation of the same laws under analogous conditions as those which produce the property known in mineralogy and crystallography as cleavage.

At first one would suppose wax, or baker's dough, to be most unlikely substances wherein to detect any tendency to cleavage; yet it is precisely with these materials, wherein plasticity is a most prominent physical property, that Professor Tyndall has performed experiments that are commanding the attention of the scientific world, and the results of which have an important bearing upon the metallic processes. In these plastic materials and others, such as clay and graphite, Professor Tyndall has proved that cleavage may be developed in as marked a degree as in slate—even the varieties of the latter used for roofing—by the simple application of pressure to the plastic mass. Cakes of wax that have been thus treated are easily split up into regular laminæ, so uniform in character as

to excite the surprise and admiration of those who have witnessed the experiments.

These researches appear to have proved that any material, no matter how plastic or how homogeneous it may appear to be, has within it the condition for the development of cleavage, and that the only external condition necessary to produce lamination is a sufficient degree of pressure exerted in one direction upon the mass. The resulting planes of cleavage will be at right angles with the direction in which the pressure is applied. The philosophy of this effect lies in the fact that, as relates to the cohesion of its particles, no substance is strictly homogeneous; that is to say, the particles, granules or molecules of substances do not possess cohesive power equally in all directions; and hence, when pressure is applied to them, they slide over each other (the sliding surfaces being those of least cohesive power) and move toward a point of less pressure. In the case wherein pressure is applied in one direction only, the sliding will be in a direction at right angles with the

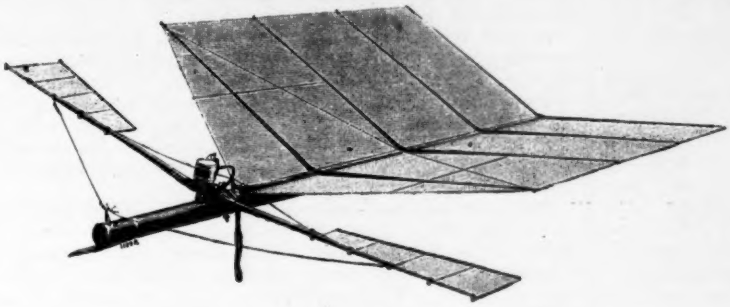
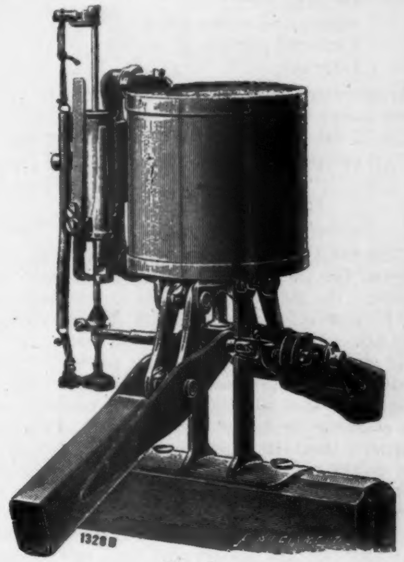
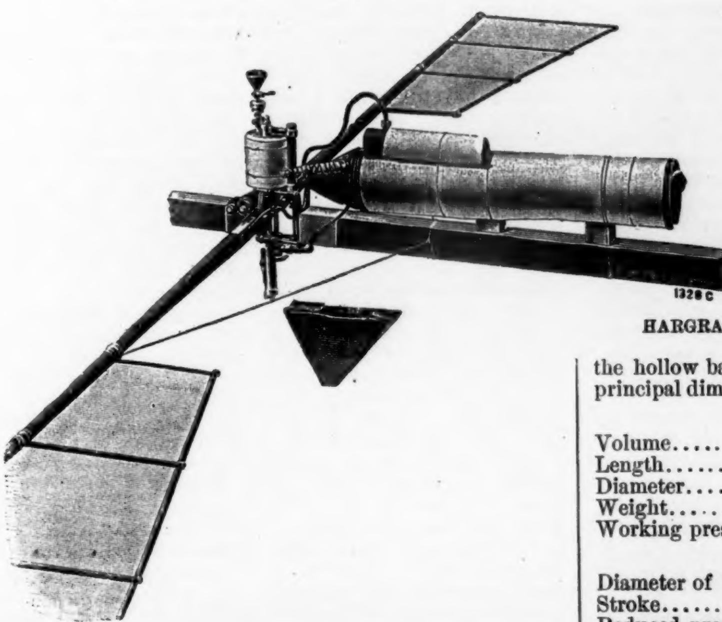


Fig. 1.



.Fig. 2.



HARGRAVE'S FLYING MACHINE.

direction of the pressure, and thus plates, laminæ or strata are generated in the mass, the limiting faces of these layers having less cohesion than their interior parts.

It is thus that under the action of the rolling pin flaky pie crust is formed. The same kind of stratification is formed in a biscuit, while in bread, the loaves of which are shaped by kneading, this stratification is absent, and a fibrous structure —called by bakers the "pile"—results from the difference in the manipulation. It is entirely indifferent what kind of material is thus operated upon, provided that it will in some degree yield to pressure without crushing into powder; the result of pressure exerted in one direction more than in any other will result in lamination more or less marked. A practical illustration of this kind of action is found in iron and other metals. When iron undergoes the ordinary process of rolling it is taken at a welding heat from the furnace, and the uniformly distributed heat weakens the cohesive power of the particles quite equally throughout the mass; the result is a fairly homogeneous bar or plate. However, in bars the tendency to longitudinal stratification is manifest, and when the bars are cold and cohesion has again been restored to its normal power, it can always be found that iron so produced is stronger longitudinally than laterally.—*American Gaslight Journal.*

## HARGRAVE'S FLYING MACHINE.

We have on several occasions noticed the flying machines constructed by Mr. Lawrence Hargrave, and described by him before the Royal Society of New South Wales. All these have been wonderful pieces of mechanism, combining lightness with rigidity in a marked degree, and each has been a distinct advance over its predecessors. The accompanying illustrations show three of the more recent types. Fig. 1 shows the general appearance of these machines. A backbone carries two outstretched stationary wings or aeroplanes, which glide over the air, while in front are two flapping wings, which afford the propelling power. These wings are driven by an engine, whose motive fluid is compressed air, stored in the hollow backbone of the machine. The following are the principal dimensions:

| | |
|---|---|
| **Pressure Container.** | |
| Volume | 251 cub. in. |
| Length | 6 ft. 11 in. |
| Diameter | 2 in. |
| Weight | 15½ oz. |
| Working pressure | 250 lb. per sq. in. |
| **Motor.** | |
| Diameter of cylinder | 2 in. |
| Stroke | 1.28 in. |
| Reduced pressure | 57 lbs. |
| Weight of engine | 11 oz. |
| Efficiency | .29 |
| **Machine.** | |
| Length of wing | 31 in. |
| Area of wings | 216 sq. in. |
| " of body plane | 3074 " " |
| " in advance of the center of gravity | 732 " " |
| Total weight, charged | 59 oz. |

Five hundred and nine foot-pounds of work produced 46 double vibrations, which drove the machine 512 ft.

Fig. 2 shows another form of engine having a cylinder 2 in. in diameter by 1¼ in. stroke, and working at a pressure of 60 lbs. per square inch. Its weight is 9 oz. The machine fitted with this engine on one occasion flew 343 ft. in 23 seconds, with 54½ double vibrations of the engine. It was estimated that 742 ft. lbs. of work were done in driving the machine at 10.1 miles per hour.

The success which had been attained by the compressed air motors encouraged Mr. Hargrave to try steam. The conditions he laid down to be fulfilled were that the steam motor should be lighter than the compressed air apparatus, that it

should have a uniform boiler pressure, and flap the wings of the standard size as fast as the compressed air engine and for a longer time. The Serpollet boiler was adopted, and as steel pipe could not be got in Sydney, copper pipe of ordinary trade sizes was procured. Many boilers were made and rejected; the one in the figure is a two-stranded coil, containing 12 ft. of pipe, ½ in. outside diameter, weighing 20½ oz., with steam and water connections. Methylated spirits of wine was adopted as the fuel, and was stored in the small cylindrical reservoir shown in the figure. The boiler was inclosed in a cylinder of asbestos card, and the vaporized spirit mixed with air was spurted into the furnace. As much as 6.9 cub. in. of water have been evaporated by 1.7 cub. in. of spirit in 80 seconds, the engine making 182 double vibrations of the wings. The engine was of the usual type, with the addition of a feed pump, 5.2 m. in diameter, drawing out of the reservoir shown detached. The relation between the cylinder capacity and the boiler is:

| | |
|---|---|
| Cylinder | 2.2 cub. in. |
| Steam and water space of boiler | 2.8 " |
| External surface of boiler | 113 sq. in. |
| Internal " " | 71 " |

Chronograms showed that 1.66 double vibrations per second were made with 55 lbs. pressure of steam, and 1.8 per second with 75 lbs. A thrust diagram showed that:

| | |
|---|---|
| 2.2 vibrations per second produced a thrust of | .75 lb. |
| 2.3 " " " | .90 " |
| " " " | 1.10 " |
| " " " | 1.25 " |

The total weight of the apparatus is 64.5 oz., which includes 12¾ oz. for the strut and body plane, and 5 oz. for spirits and water. By aid of an ingenius indicator it was found that .169 H. P. is developed when 2.35 double vibrations are made per second.

If the machine were loaded up with 10 oz. more spirit and water, it is calculated, from data obtained from previous machines, that it would have a possible range of 1,640 yds. On starting the boiler is empty, and is warmed up by a Bunsen burner; then the spirit-holder is heated till the flame ignites, the flame being maintained by a few shreds of asbestos put into the coil. When the flame is under way part of the boiler gets red hot in a few seconds. Then the wings are moved up and down a few times by hand, squirting about a teaspoonful of water into the boiler, and then the engine starts.

Every one must admire Mr. Hargrave's great skill as a mechanic, and the marvellous patience he brings to this subject of mechanical flight. If it had always been attacked in his spirit it would have escaped much ridicule, and greater progress would have been made. As it is, very great advance has been made during the last two or three years, since the matter has fallen into the hands of skilled mechanics, and further developments are to be looked for.—*Engineering*.

## MANGANESE STEEL.*

By Henry M. Howe.

Manganese steel is an alloy of iron with from, say, 3 to 20 per cent. of manganese. Certain varieties of it are extremely ductile, and yet very strong and extremely and unchangeably hard. This combination of simultaneous hardness and ductility is, I believe, quite unique.

Common or carbon steel may be extremely ductile in its annealed state, and extremely hard in its hardened state; while the self-hardening steels are nearly unchangeably hard, but always brittle. I know of no substance, organic or inorganic, except manganese steel, which is at one and the same time both hard and ductile. Indeed, hardness and brittleness usually go hand in hand to such a degree that the word "hard" is often carelessly used in the sense of "brittle." And I believe that not a few of us have, by association, come to regard hardness and ductility as in some way absolutely incompatible.

Manganese steel was discovered and patented by Robert Hadfield, and to him and his son we owe most of our information about it.

Manganese steel conducts both heat and electricity extremely badly, and is but faintly magnetizable.

The influence of manganese on the properties of the alloy is probably profoundly influenced by that of the carbon, which at present unavoidably increases with the manganese. We cannot now make 13 per cent. manganese steel with much less than 1 per cent. of carbon; and we can only guess what its properties would be without this carbon.

* A lecture delivered before the Franklin Institute, February 20, 1892.

Let us consider some of the properties to which I have thus referred, and later the preparation and the uses, actual and anticipated, of this remarkable material.

Its properties vary strikingly with the proportion of manganese which it contains, and with the treatment it has undergone. Except where the contrary is explicitly stated, I confine myself to-night to the alloy containing about 13 per cent. of manganese, in its ductile or "water-toughened" state.

Let us first consider the tensile properties of manganese steel, its tensile strength, both elastic and ultimate, and the ductility which a bar of it displays when torn apart longitudinally or tensilely, as in the most common form of tests for engineering and scientific purposes. The general worth or merit of any particular lot of iron or steel is usually measured by its combination of strength with ductility. I do not now speak of its fitness for this or that particular purpose, but of its general merit. The scientific investigator needs one set of qualities; the poet, a second; the statesman, a third. Nevertheless, there are common standards which we apply to all, as measuring their general merit as men.

In case of carbon steel, at one extreme we have metal of enormous strength, but so brittle and treacherous that the engineer dare not use it. At the other, we have metal of extraordinary ductility, but so weak as to be of little value for many purposes. So, in a rough way, we habitually regard that steel which has the greatest strength for given ductility, or that which is the most ductile for given strength, as the best.

The most common measure of ductility is the permanent elongation which a bar of the metal undergoes when it is pulled in two by direct longitudinal stress; and this elongation is habitually measured in percentages of the initial length of the bar tested. The combination, then, of tensile strength with the permanent elongation on tensile rupture, or, in short, of strength and elongation, is the standard by which I first ask you to judge the excellence of manganese steel.

In fig. 1 I have represented this combination graphically for manganese steel, and for many of the best reported specimens of common or carbon steel. (To distinguish common steel from manganese steel, I shall speak of it in this lecture as carbon steel.) In this diagram the ordinates, or the vertical distances of the several spots from the horizontal axis, indicate the ductility as measured by the permanent elongation undergone by a given test piece prior to rupture; the abscissæ —*i.e.*, the horizontal distances of the several spots from the vertical axis, indicate tensile strength. The little black spots represent the properties of carbon steel, and you note that they fall in a tolerably well-defined band, the elongation diminishing as the tensile strength increases.

Note, however, how greatly the manganese steel specimens excel those of carbon steel in their combination of strength with ductility. For a tensile strength of from 130,000 to 150,000 lbs. per square inch, none of the carbon steels have more than 16 per cent. of elongation; while many of the manganese steels of this strength have an elongation of 45 per cent., and some even of 50 per cent.*

But I think that this combination, which we have been considering, ultimate strength with ductility, is by no means so good a measure of general merit as the combination of ductility with elastic strength, or tensile strength within the limit of elasticity, or, as it is called, elastic limit. The elastic limit measures the power of the metal to resist stress without becoming permanently deformed. It is this, probably, rather than the ultimate tensile strength, that should, and some day will, determine the stress to which the material shall be exposed in practice. The ultimate strength of the material measures the stress, a single brief application of which will tear it apart; the elastic strength or elastic limit seems to measure the stress which, if indefinitely prolonged or repeated, will tear it apart. Now, if this be true, no matter how great the ultimate strength, we should not dare to expose materials indefinitely to a stress as great as their elastic limit.

Therefore, in fig. 2, I have in like manner represented the combination of elastic limit with elongation in case of carbon steel, of manganese steel and of nickel steel. The little spots for carbon steel as before fall in a band running obliquely across the diagram, less clearly defined because of the smaller number of cases.

* Since this lecture was delivered still more extraordinary combinations of strength and ductility in case of manganese steel have been reported. Mr. E. G. Spilsbury found in case of one specimen of wire a tensile strength of 400,000 pounds per square inch, with an elongation of thirty-three per cent. in six inches. An extraordinary case of ductility is reported by the same gentleman. Wire of No. 18 gauge, 0.046 inch in diameter, endured forty-eight twists in a length of six inches, and twenty-two bends. Its tensile strength was 155,000 pounds per square inch, and its elongation seventeen per cent. in six inches. These are picked results; in the first of them an error is possible, though extremely improbable.

Two of the triangles, indicating nickel steel, lie well above the band of carbon steel; but even these are excelled by many of the circles which stand for manganese steel. [Since this lecture was read, other tests of nickel steel have come to my notice, in which this combination is as great as it is in the cases of manganese steel represented in fig. 2.]

These comparisons may, however, give a false idea of the ductility of manganese steel. If two metals elongate in a like manner, the extent of their elongation may be a fair comparative measure of their ductility; not necessarily so, however, when their mode of elongating is unlike in kind. A bar of

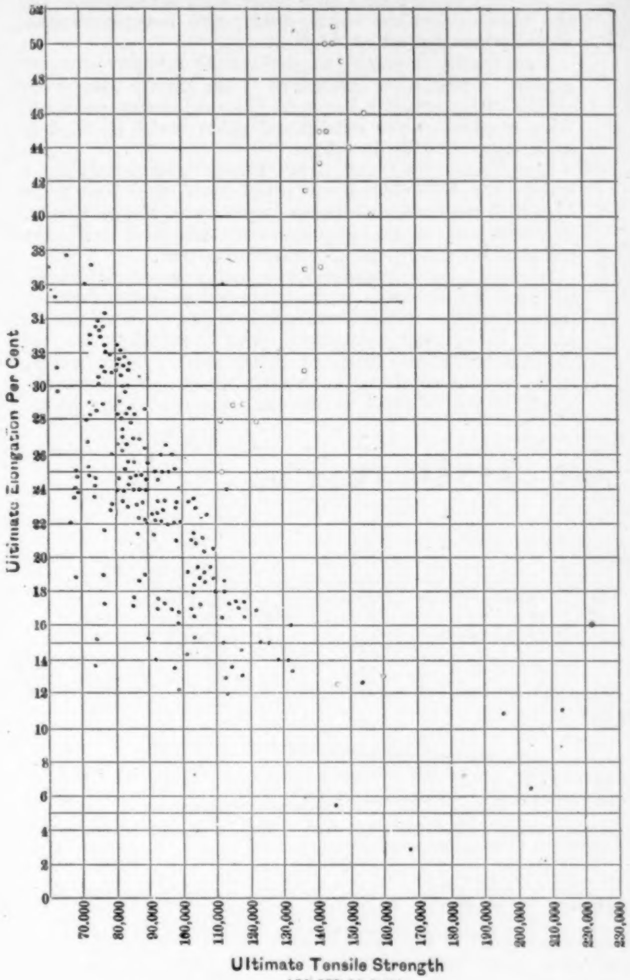



Fig. 1.

0 = Water-toughened manganese steel.
∴ = Carbon steel.

TENSILE PROPERTIES OF CARBON STEEL AND OF MANGANESE STEEL.

carbon steel habitually yields when pulled in two by "necking," contracting greatly just about the place where rupture occurs, as shown in fig. 3, while a bar of manganese steel or of brass elongates far more uniformly over its whole length. For some purposes this uniform stretch may be better, for others worse, than the necking and localized stretch of carbon steel; suffice it here to point out that the two are different, and, therefore, not strictly comparable as a measure of ductility; and further, that, thanks to the nearly uniform stretch of manganese steel over the whole length of the test bar, its percentage of elongation may be held to give an exaggerated idea of the metal's true ductility or plasticity.

This granted, it yet remains that the metal is very ductile and has great strength, both elastic and ultimate.

This leads me to speak of a further peculiarity of the ductility of manganese steel, the difficulty with which cracks are propagated across it—*i.e.*, its non-fissility. This is illustrated by fig. 4, in which are sketched the condition of one and the same test bar of manganese steel, in different stages of elongation under tensile stress. The stretching was interrupted several times, and each time the test bar was water-toughened—*i.e.*, was heated to redness and then plunged in water. You will note, first, the uniform stretch over the whole length of the test-piece, in marked contrast to the necking of carbon steel shown in fig. 3. Next you will notice three rough diamond-shaped figures in each of the lower three sketches. These are deep holes, unexpectedly resulting from the stretching of very light prick-punch marks; one of them is more than $\frac{1}{16}$ in. deep, and $\frac{1}{4}$ in. across. That so hard a material should tear in this way is most surprising. In one case daylight could be seen through a test bar while it was still enduring a tensile stress of over 110,000 lbs. per square inch.

So in testing manganese-steel knuckles for automatic car-couplers, by an impact or drop test, it has been noted that, after the metal has begun to crack, it endures a surprising number of blows before breaking.

The way in which the tensile strength, and more especially the ductility of manganese steel, vary as the percentage of manganese increases, is very striking. As the manganese rises, the ductility at first diminishes very suddenly. It has long been believed that the presence of 1.5 per cent. of manganese made common carbon steel brittle. As early as 1877 a case came to my notice in which, by an error, a lot of rail steel, which should have contained about 1 per cent. of manganese, actually contained about 1.5 per cent., its composition being normal in other respects. It was dangerously brittle.

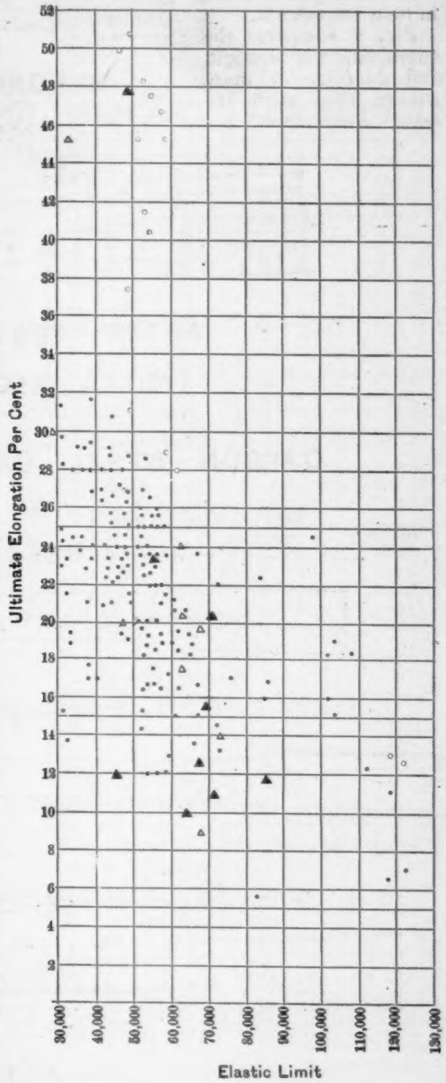



Fig. 2.

• = Carbon steel.
0 = Water-toughened manganese steel.
▲ = Rolled nickel steel.
△ = Rolled and annealed nickel steel.

TENSILE PROPERTIES OF CARBON, MANGANESE AND NICKEL STEEL.

With further increase of manganese, the metal becomes more and more brittle. Manganese steel with from 4 to 6.5 per cent. of manganese, under certain special conditions, is so brittle that it can be pulverized with a hand hammer. But, as the manganese rises above 7 per cent., the ductility of the water-toughened metal increases in a most striking way, till the manganese reaches about 13 per cent. With further increase of manganese the ductility again diminishes, perhaps as fast as it had risen. This is illustrated graphically in fig. 5, by a curve indicating roughly the elongation to be expected in water-toughened pieces.

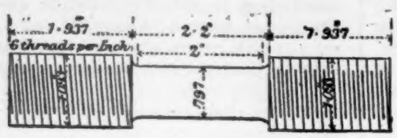
Fig. 6 shows in like manner how the tensile strength of water-toughened manganese steel, very low when there is some 7 per cent. of manganese present, rises rapidly, reaching a maximum when the manganese reaches somewhere about 14 per cent., and again diminishing with further increase of manganese.

Returning again to fig. 5, we note that the strength and ductility reach their maxima with about the same percentage of manganese.

But, though striking, the reversal of the effects of increments of manganese on the physical properties of the alloy, as its content of manganese rises above 14 per cent., is by no means astonishing; for like cases are reported with other alloys. Thus a slight addition of zinc is reported to lessen the malleableness of copper, while a larger addition in turn increases it.

Fig. 7 compares the combination of strength and ductility of manganese steel with the same combination for nickel steel. The circles as before represent manganese steel, the triangles nickel steel. The combination as thus measured is seen to be on the whole much greater in manganese steel than in nickel steel. But this does not at all prove that manganese steel is better than nickel steel.

While manganese steel is intensely and astonishingly hard, considering its ductility, it is not as hard as chilled cast iron, nor as the hardest grades of carbon steel when they are dead hardened, that is to say, brought to their very hardest state by quenching in water. Manganese steel containing some 7 per cent. of manganese, indeed, is so hard that it can be used for cutting iron; and lathe tools made from it have been used successfully. But the 13 per cent. manganese steel, with which we concern ourselves this evening, is far from hard enough for this purpose.




BEFORE TESTING


AFTER TESTING

113.77% ELONGATION

CARBON STEEL BAR BEFORE AND AFTER TESTING

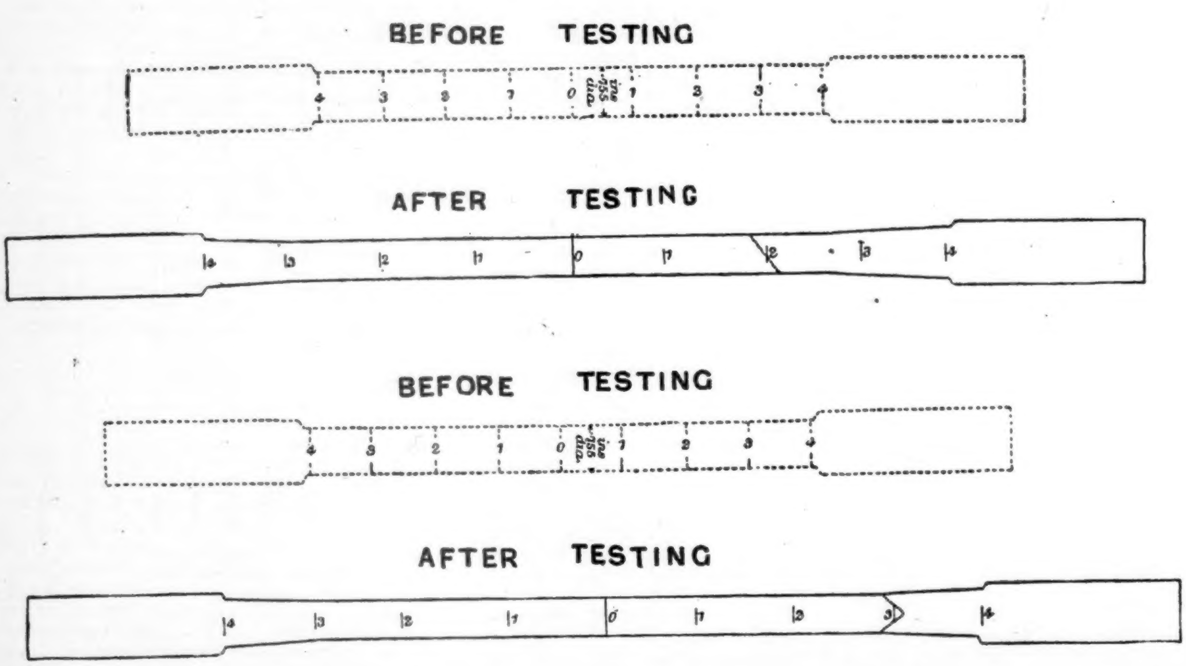



FIG 3 MANGANESE STEEL BARS BEFORE AND AFTER TENSILE TEST

Moreover, the very fact that it is accompanied by great ductility makes its hardness peculiar. We are accustomed to think of very hard bodies as incapable of being indented, as, for instance, by the blow of a hammer; but manganese steel can be thus indented. This, however, is a necessary consequence of its ductility. Most very hard bodies, such as glass, hardened steel or chilled cast iron, if they receive a blow which passes their compressive elastic limit, simply break or crack; that is because they are not ductile; they cannot yield. Manganese steel, however, on receiving such a blow simply yields. Within its elastic limit it behaves under blows like other hard substances. Let the blow exceed the elastic limit, and manganese steel yields where the others break.

I am hardly prepared to give a clear account of its rigidity. Under some conditions it has shown itself very rigid; under others it has not. As yet I cannot point out with confidence the conditions which make it rigid in some cases, but not in others.

Manganese steel car axles, struck transversely by a heavy ram, have been found much more rigid than those of carbon steel, with which they were tested competitively. Yet stamp shoes and horse-shoes of manganese steel have not thus far shown the endurance expected.

In resistance to abrasion alone, manganese steel excels the hard carbon steels (when unhardened) and, *a fortiori*, the soft steels. Where both abrasion and repeated shocks are to be resisted, manganese steel is certainly far less liable to break than the hard carbon steels; but whether, under new conditions combining shock and abrasion, it will prove as rigid as the carbon steels, with which it will then have to compete, direct experiment alone can tell.

Its magnetic properties, or their absence, are among the most surprising things concerning this surprising substance. While manganese steel of 9 per cent. of manganese is attracted by the magnet when finely divided, yet that of 13 per cent. is for all practical purposes unmagnetizable. With moderate magnetizing force, its susceptibility to magnetic influences is, according to Ewing, only about $\frac{1}{5000}$ that of soft iron. "No magnetizing force to which the metal is likely to be subjected in any of its practical applications will produce more than the most infinitesimal degree of magnetization." Yet with enormous magnetizing force, for instance, of 10,000 C. G. S. units, it is possible to magnetize manganese steel very considerably.

If its resistance to magnetization is great, so is its resistance

to the passage of heat and of electricity. Of each it is a very poor conductor.

Fig. 8, from determinations kindly made by the Thomson-Houston Electric Company, of Lynn, Mass., comparing the electric resistance of manganese steel with that of copper and of soft iron at different temperatures, shows that the resistance of manganese steel at 0° C. is nearly seven times that of soft iron, and is very much less affected by changes of temperature than the resistance of either soft iron or copper. Its resistance is about double that of platinoid, and thrice that of German silver.

*Preparation.*—Manganese steel of the class that I am describing to-night is made by stirring together the molten, thoroughly decarburized product of the open-hearth or Bessemer process and molten, highly heated, rich ferro-manganese. Care must be taken to avoid loss of manganese, and to keep the proportion of carbon down. The product should have not less than 11 per cent. of manganese, and not more than 1.25 per cent. of carbon. If we can give it as much as 13 per cent. of manganese and less than 1 per cent. of carbon, it will be better for most purposes. So high a ratio of manganese to carbon can be had only through great care.

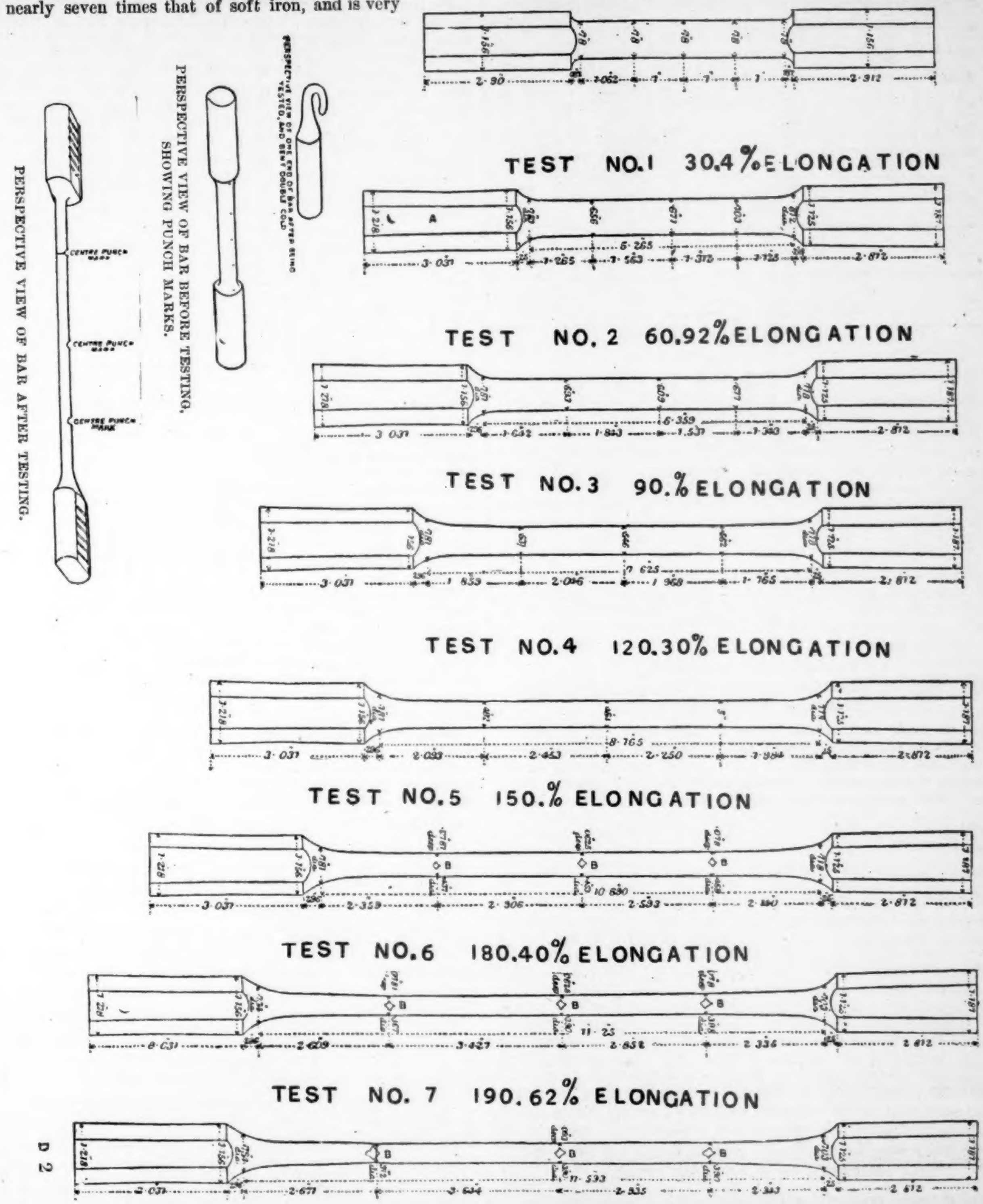



Fig. 4.

APPEARANCE OF A SINGLE TEST-BAR OF MANGANESE STEEL, BEFORE AND AFTER REPEATED STRETCHING, EACH FOLLOWED BY WATER-TOUGHENING.

The high cost of metallic manganese puts it beyond our reach as a material for making manganese steel. The only present available source of manganese for this purpose is the carburetted alloy of iron and manganese called ferro-man-

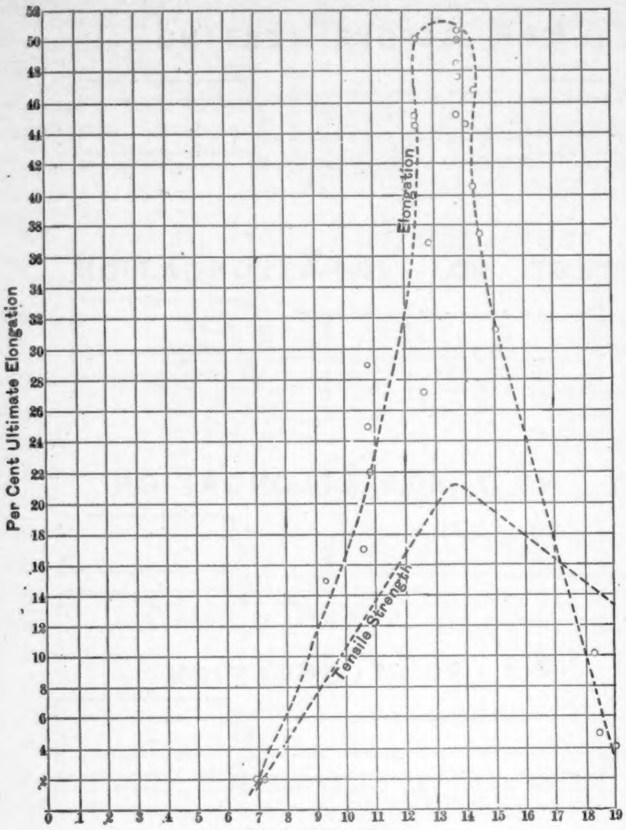



Fig. 5

0 = Water-toughened manganese steel.

INFLUENCE OF THE PERCENTAGE OF MANGANESE ON THE DUCTILITY OF MANGANESE STEEL.

ganese, made in the iron blast furnace from ore of manganese. It usually contains about 80 per cent. of manganese, 6 per cent. of carbon, and 13 per cent. of iron, though occasionally the proportion of manganese rises to beyond 87 per cent., with as little as 7 per cent. of iron.

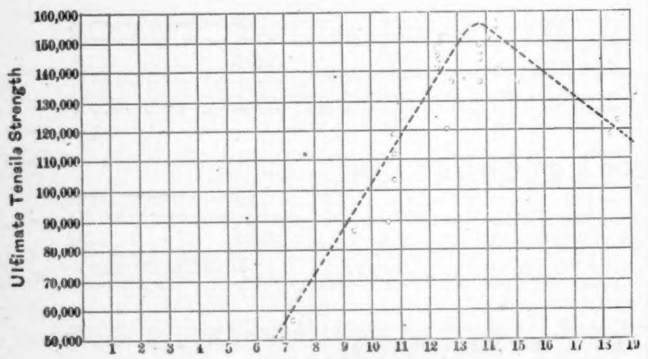



Fig. 6.

INFLUENCE OF THE PROPORTION OF MANGANESE ON THE TENSILE STRENGTH OF MANGANESE STEEL.

These crude products of the blast furnace necessarily contain so much carbon, absorbed directly or indirectly from the fuel, that even those richest in manganese are barely rich enough. The difficulty is to get into the steel as much manganese as it needs, without incidentally introducing an excessive and injurious quantity of carbon. For the requirements just given as to the composition imply that the steel should contain at least nine times, and better 13 times, as much manganese as carbon. Even if we make no allowance for the fact that the molten decarburized iron usually contains much more carbon than manganese, and that an appreciable quantity of manganese is lost by oxidation in alloying the molten components, this implies that, as the ferro-manganese usually contains at least 6 per cent. of carbon, it must contain at least $9 \times 6 = 54$ per cent., and better $13 \times 6 = 78$ per cent. of manganese.

In short, to avoid having in our steel more carbon than is desirable, we must use a ferro-manganese as rich as possible in manganese, and alloy it with iron containing as little carbon as possible.

Such iron is that made either in the Bessemer process or in the open-hearth process, by thoroughly decarburizing cast iron. In making merchantable steel (other than manganese steel) by either of these processes, a little carbon or manganese, or both, must actually be added to this thoroughly decarburized iron, in order to make it malleable, for reasons which we need not here consider. But in making manganese steel we deal with simply this thoroughly decarburized iron.

The loss of manganese in preparing manganese steel, according to Hadfield, equals about 0.50 per cent. of the total weight of the decarburized iron plus ferro-manganese used—*e.g.*, if the charge should by calculation, and without allowing for loss of manganese, contain 13.5 per cent. of manganese, it will actually contain about 13 per cent.

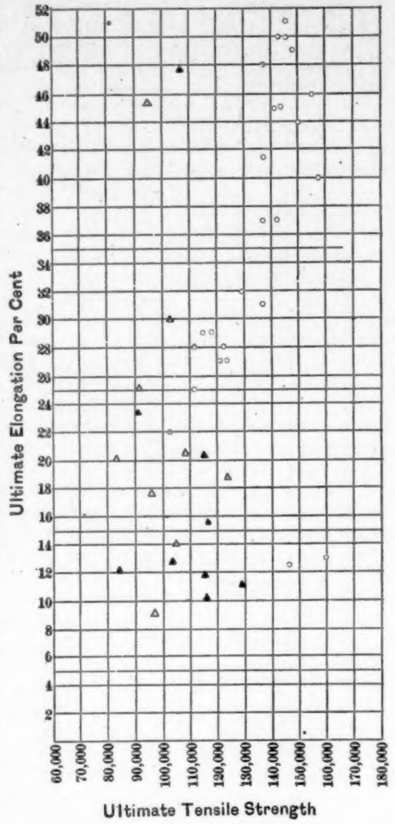



Fig. 7.

0 = Water-toughened manganese steel.
▲ = Rolled nickel steel.
△ = Rolled and annealed nickel steel.

TENSILE PROPERTIES OF MANGANESE STEEL AND NICKEL STEEL.

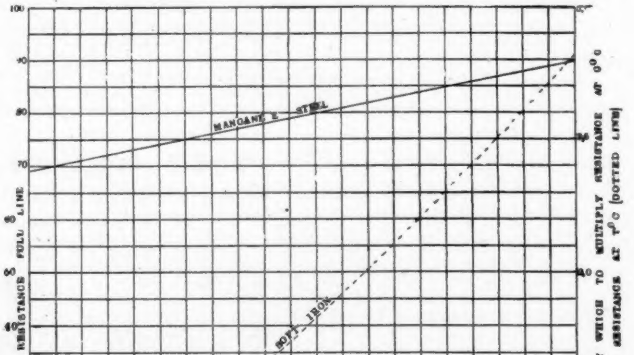



Fig. 8.

ELECTRICAL RESISTANCE OF MANGANESE STEEL, COPPER AND IRON.

After carefully mixing the molten iron and ferro-manganese, they are poured into suitable molds of iron or sand, as the case

may be. Large ingots are habitually cast in iron molds; and here an important precaution must be observed.

Thanks to the slowness with which this metal conducts heat, the outside of the ingot, in contact with the cold walls of the iron mold, cools so far as to be rigid and incompressible, while the interior of the ingot is still far above its melting-point. In cooling from this exalted temperature the molten, and later the solidified metal of the interior, undergoes great contraction, and no longer suffices to fill completely the outer shell of the ingot. Hence arises a deep vacuous cavity in its center, known as the "pipe." To meet this, the top of the ingot is covered with charcoal, so as to keep its upper surface molten, and fresh lots of molten manganese steel are from time to time added, in order to fill this cavity or pipe.

*Treatment.*—We now pass on to consider the treatment of manganese steel. In what may be termed its natural state—*i.e.*, when slowly cooled either from the initial heat of casting or after forging, *manganese steel is brittle.* The ductility which gives it value is obtained only by sudden cooling from a high temperature—*e.g.*, by plunging it while red-hot into cold water.

We are all familiar with the remarkable effect of suddenly cooling common steel, as, for instance, by plunging it while red-hot into water or oil; we all know how this hardens the metal, makes it relatively brittle, and, if judiciously performed, strengthens it. (In speaking of hardness, I invariably refer to the hardness proper, the resistance to indentation and abrasion.)

But the effects of sudden cooling on manganese steel and on carbon steel are in some respects very unlike. The tensile strength and elastic limit of both may, indeed, be greatly raised by sudden cooling; but even here a difference is noticeable. For while sudden cooling, even if very sudden, indeed violent, increases the strength of manganese steel greatly, the rate and conditions of cooling must, in case of carbon steel, be carefully regulated if great strength be sought; and indeed very sudden cooling may actually greatly weaken carbon steel, and require a subsequent tempering—that is to say, mitigating, or letting down.

When, however, we turn to the effects of sudden cooling on the hardness proper and the ductility of these two substances, carbon steel and manganese steel, we find a most marked difference. Sudden cooling hardens carbon steel greatly, and may make it so hard that it scratches glass readily; if it affects the hardness proper of manganese steel at all, its effect is so slight as to be detected only by delicate tests. Sudden cooling tends to lessen, and if very sudden may quite destroy the ductility of carbon steel, leaving the metal as incapable of receiving permanent set as glass is. Yet the same sudden cooling increases the ductility of manganese steel astonishingly.

Fig. 5 illustrates graphically the influence of sudden cooling on the ductility of manganese steel. Here the properties of manganese steel in its natural state are indicated by black semicircles, the circles indicating the properties of the metal when suddenly cooled by quenching in water, or, as it is called, "water toughened." We see that, while the elongation of the metal in its natural state is usually below 5 per cent., that of the water-toughened material rises occasionally to 50 per cent.

Fig. 6 illustrates in like manner the influence of sudden cooling or water-toughening on the tensile strength. We note that, while the tensile strength of the metal in its natural state, as indicated by the black semicircles, rarely rises above 100,000 lbs. per square inch, that of the water-toughened metal, indicated by the circles, is usually above 110,000 lbs., and rises to even above 150,000 lbs. per square inch.

(TO BE CONTINUED.)

## CROSSINGS OF GREAT RIVERS.

### A CONTRIBUTION TO RAILROAD LOCATION.

By A. Zdziarski, C.E.

### APPENDIX.

#### THE HYDROMETRIC APPARATUS OF AMSLER.

As we have said in the chapter on the Measurement of Velocities,* the most suitable apparatus for measuring the velocities of current at different depths is the hydrometric apparatus of Amsler, or more exactly of J. Amsler-Laffon of Schaffhausen. We do not think that this apparatus is as well known among American engineers as it deserves, and we therefore present a detailed description of it.

* See Railroad and Engineering Journal, September, 1892, p. 403.

The hydrometric apparatus of Amsler-Laffon consists of three distinct parts:

1. The mill, with a registering apparatus and the electric contact.
2. The electric signal, with its battery and conductors.
3. The winch, with weight for working at great depths.

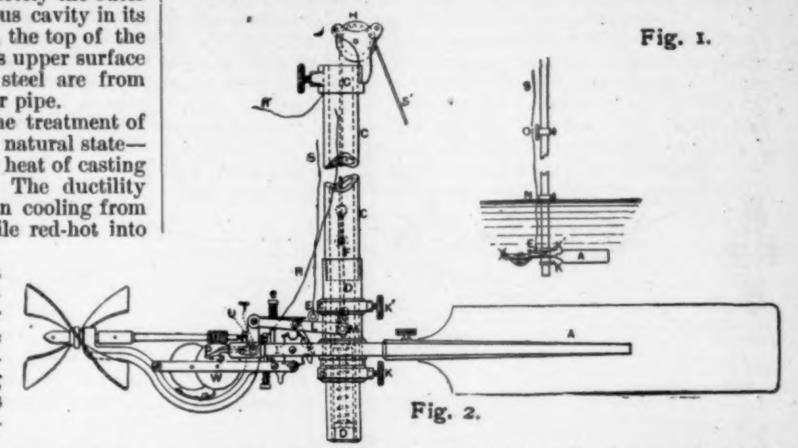


Fig. 1.

Fig. 2.

1. *The Mill.*—The mill consists of a pair of helicoidal blades (figs. 1 and 2) fixed on a horizontal shaft, and put in rotatory motion by the current of water. The shaft carries an endless screw, which by means of gearing communicates the motion to the registering apparatus, consisting of a divided wheel with an index. The wings, gearing and counter are fixed on a metallic frame, the opposite end of which carries a plane or conical rudder. The whole is supported by means of a vertical rod, a gas-pipe, or by means of steel wire stretched by a weight.

When the depth of water is not great the mill can be used in the same way as the other old hydrometric apparatus of Woltmann-Baumgarten, being drawn from the water in order to read the counter every time such reading is necessary. For this purpose the whole apparatus, with the plane rudder *A* (fig. 1), is put on a vertical rod and fastened by means of screws *K K'*. The lower end of the string *S*, serving to lock and unlock the register, is fixed to the eye *E* of a horizontal lever. Every time this string is quickly pulled the register is locked or unlocked. Of course before the apparatus is sunk the register must be unlocked and the position of index noted. When the apparatus is immersed, the counter is allowed to run for a definite time, say, from one to three minutes, which is done by pulling the string at the beginning and the end of this interval. The apparatus is then drawn from the water, and the number of revolutions of the blade is read on the register.

In greater depths this process is not certain enough, because when the apparatus is sunk to a great depth the current can stretch the string so that it will lock the register, and we can never be sure whether it is locked or unlocked. In order to avoid this, it is better to use, instead of a wooden rod, a ¾-in. gas-pipe *C*, screwed into a foot-piece *D* (fig. 2), to which the mill can be fixed by means of screws *K K'*, a cylindrical piece *c d*, and a round nut *d*. The string *S'* is now placed inside of the pipe *C*, and its lower end, provided with a carabin-hook, is passed through the eye *F* of the lever *L*. The string *S'* is put inside of the pipe *C* and connected with the lever *L* in the following manner: The pipe *C*, without the foot-piece *D*, is held in an inclined position, and the lower end of the string with the hook is put in the upper end of the pipe; then the hook, going before the string, pulls it down to the lower end of the pipe. The hook is then connected with the eye *F*, and the foot-piece *D* is screwed to the pipe *C*. To the upper end of the pipe a ring *G* with a pulley *H* is fixed, and the string *S'* passed over it.

The mill is now put on the foot-piece *D* and fastened by means of two screws *K*, *K'* in such manner that the points of the screws enter the conical holes drilled in the foot-piece. The locking lever *L* is connected with the string *S'* by means of a cross-pin *M*, which is driven through the holes of the lever and screwed. The counter is operated by pulling the string *S'* in the above described manner.

The ring *N* and the disk visor *O* (fig. 1) can be strengthened by screwing to the gas-pipe. The ring *N* marks the depth at which the velocity is measured, and it is so fixed that during the experiment it is at the surface of water. The disk visor

*O* is fastened in such position that the plane of disk is at right angles to the shaft of the mill, and thus the disk indicates the direction of the mill under the water.

2. *The Electric Signal.*—The above-described manner of measuring the velocity of current is very tiresome, because the apparatus for reading the register must be frequently drawn from the water. In order to avoid these inconveniences, the apparatus with electric signal was devised.

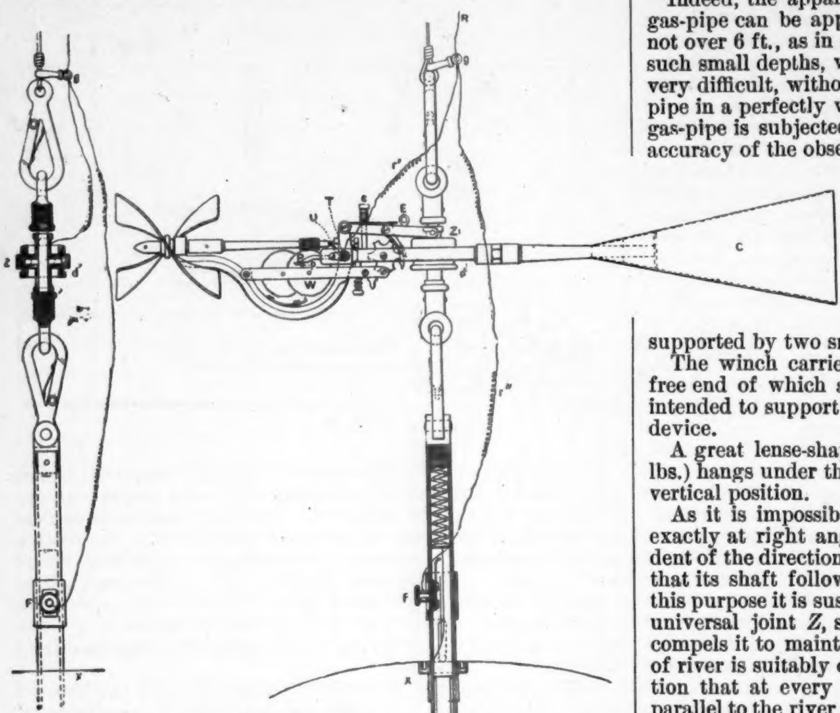


Fig. 3.

The electric signal consists of three distinct parts: (1) The electric contact *P* (fig. 2); (2) the box *Q* (figs. 4, 5, 6) containing an electric bell and a small galvanic battery of two cells; and (3) suitable conducting wires.

The electric contact *P* (fig. 2) consists of a metallic lever *P*, fixed to the frame of the apparatus, but insulated from it in *T* by means of an ivory ring and plate; and of a pin *p* belonging to the wheel *W*, and touching the lever *P* after every 100 revolutions of the blade.

The box *Q* (fig. 4) has two terminals *a a'*. One of them (*a*) is, by means of the insulated wire *R* (fig. 2) and the insulated pin *U* connected with the contact lever *P*; the other terminal *a'* by means of a small wire *R'*, the gas-pipe, and the frame of the mill connects with the wheel *W* and the pin *p*. When the pin *p* touches the contact lever *P* the electric bell sounds, and the observer notes the time, preferably with a stop-watch.

Before sinking the apparatus in water, the register is locked and the worm on the shaft of the mill made to mesh with the toothed wheel *W*. Thus when the mill has made 100 revolutions, the electric contact *P* is locked and the bell sounds. It is to be noted that as the sounding of the bell lasts a certain length of time, it is advisable to note the end of the sounding, which is much more easily and exactly performed than to note its beginning. The interval of time between two observed ringings, say, *T* seconds, will correspond to 100 revolutions of the blades, and the number of revolutions in a second is

$$n = \frac{100}{T}.$$

The velocity of current is then calculated by the well-known formula

$$v = a + C\,n,$$

where *a* and *C* are constant coefficients to be determined from experiments in stagnant water. Every apparatus has its special coefficients, and even they vary with the time. As an example I quote the coefficients of two apparatus used in 1891 by engineers of the Western Siberian Railroads (in feet).

The apparatus No. 1

$$v = 0{,}091 + 0{,}8126\,n.$$

The apparatus No. 41.

$$v = 0{,}091 + 0{,}7602\,n.$$

3. *The Winch.*—The most important improvement made in this hydrometric apparatus, and which rendered them suitable for measuring the velocity of current at great depths, is the use of a winch and wire.

Indeed, the apparatus fixed on a wooden rod or even on a gas-pipe can be applied only when the depths are small, say, not over 6 ft., as in canals and small rivers; however, even at such small depths, when the velocity of current is great, it is very difficult, without special devices, to keep the rod or gas-pipe in a perfectly vertical position. Furthermore, the rod or gas-pipe is subjected to vibrations which militate against the accuracy of the observations.

The winch *V* (figs. 4, 5, 6) consists of a drum, which is put in motion by means of toothed wheel, pinion, and handle. The number of revolutions of drum is noted by means of a divided dial and pointer.

The winch is fixed at the bow of a small boat (figs. 4, 5, 6), or on a platform supported by two small boats side by side.

The winch carries a steel wire, $\frac{1}{2}$ mm. in diameter, on the free end of which a carabin-hook is adjusted. This hook is intended to support the mill suspended by means of a special device.

A great lense-shaped cast-iron weight *X* (about 40 kil. = 88 lbs.) hangs under the apparatus and keeps the wire in a nearly vertical position.

As it is impossible to keep the mill suspended on a wire exactly at right angles to the cross-section of river, independent of the direction of water current, it is therefore so devised that its shaft follows this direction of current exactly. For this purpose it is suspended to the wire by means of the Cardan universal joint *Z*, so that the conical rudder *C* (figs. 3 and 5) compels it to maintain this position. When the cross-section of river is suitably chosen, the error arising from the supposition that at every point of the cross-section the current is parallel to the river axis and at right angles to the cross-section is very small.

As already stated, the mill is suspended to the wire by means of a special device, which consists of a joint piece *Z*, fixed to the ring-formed portion of the frame by means of a ring-shaped nut *d* (fig. 3). The upper end of this piece has an eye, which is caught by the carabin-hook of the suspension wire; the lower end has another eye for the carabin-hook of the weight.

The conductor *R*, connecting the terminal *a* of electric signal-box with the electric contact *P*, consists of an insulated wire *R* supported by means of an eye *g* (fig. 3) fixed to the lower end of the suspension wire. This suspension wire is at the same time the second conductor for the winch, and is connected with the other terminal *a'* of the electric signal. In *g* the conductor *R* divides into two conductors, one going to the lever *P* of the contact, and fixed in *V* to the mill; the other to the contact *F*, which is locked, when the lower projection of the weight touches the bottom.

During the observations made in the same cross section all these arrangements remain without change. The operation is still easier when the winch is located near the middle of the boat instead of on the bow, and the suspension wire is thrown over a pulley fixed at one end of the boat (fig. 5).

In order to measure the velocity of current at different depths of the same vertical line, the following mode of operating is followed: The weight is first sunk so slightly below the surface that the apparatus is at the level of water. The pointer of the winch dial (showing the length of unrolled wire) is then set at zero (this pointer holds by friction), the handle being stationary. Now, if by revolving the handle we unwind the wire and sink the apparatus to a certain depth, this depth is exactly indicated (in meters) on the dial of the winch. Before operating with the mill we measure the depth of the vertical. For this purpose we lower the weight to the bottom. The indication on the winch dial, increased by the distance from the shaft of mill to the bottom of weight attachment (0.5 meter), will give the exact depth of water on the vertical. The moment when the weight touches the bottom is signaled by a bell-ringing, which by its long duration differs from the periodical electric signal.

When the depth is exactly measured the observer divides them in suitable number of parts, and on depths corresponding to the points of division performs the measuring of velocity by noting the times corresponding to the periodical running of the electric bell.

## A NEW METHOD OF SMELTING AND CASTING METALS.

Mr. George Ambrose Pogson, the British Vice-Consul at Hamburg, explained to a number of gentlemen at Sheffield lately the "Taussig" system of smelting and casting metals in exhausted chambers. The system is claimed to produce, by a single process, every 15 minutes, with an expenditure of 360 cwts. of coal per 1,000 cwts. of finished cast metal, bronze, iron, steel, copper, brass, zinc, platinum, gold or silver, free of pores or bubbles. The process is effected by electricity by means of metal electrodes (flat shaped) in an exhausted furnace, large molds being set up outside the furnace, and exhausted by one process simultaneously with exhaustion of furnace. Castings up to 30 lbs. of iron have been made in the presence of Her Majesty's representatives at Hamburg, within 15 minutes, the air pump in use showing 92 per cent. exhaustion of air, ampere gauge 2,500, voltage 2½ volts. The electric current

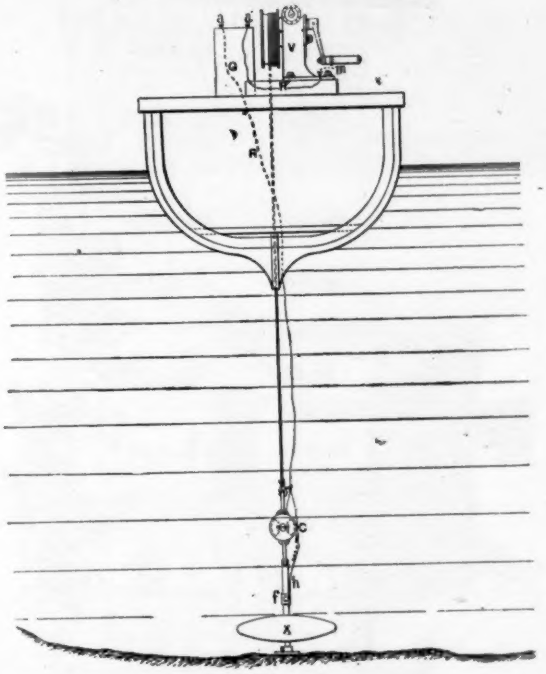


Fig. 4.

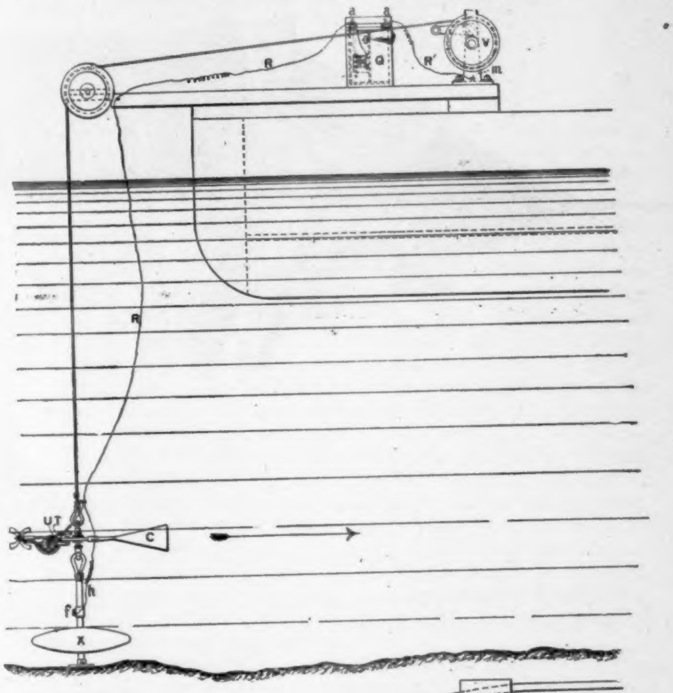


Fig. 5.

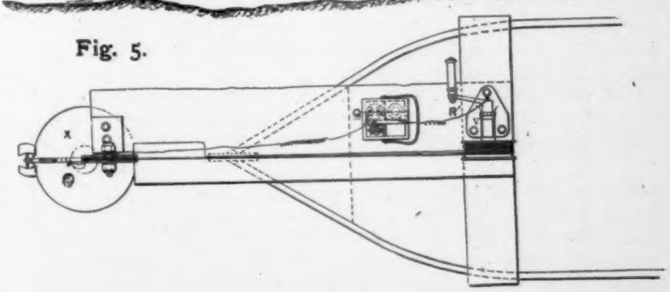
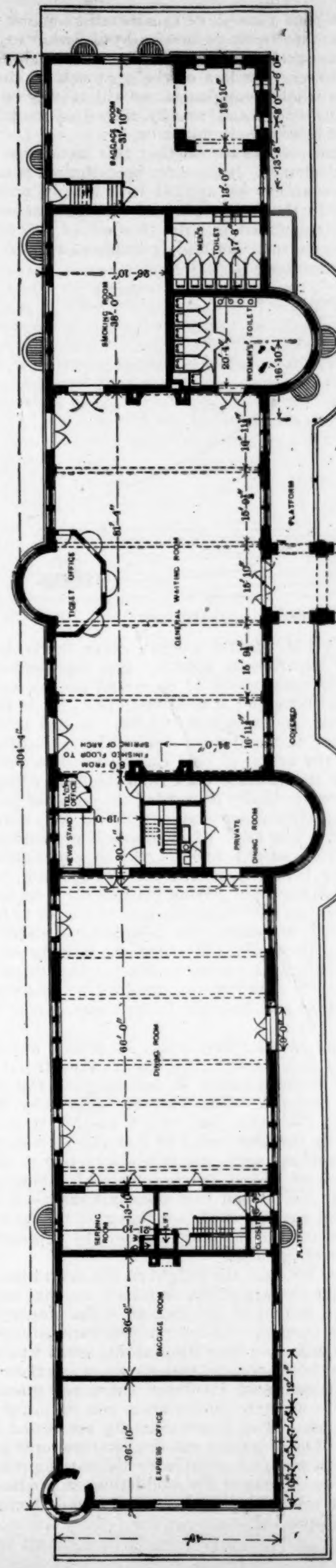


Fig. 6.

does not effect its work from outside through surface of crucible or furnace, but by conduction through the metal itself which is about to be smelted. Siemens-Martin steel is fused without other parts of the electric current undergoing any material increase of temperature. By use of metallic electrodes, all contamination of metal by carbon is absolutely avoided. As coal slack is not present in any large quantity, refuse is reduced to a minimum, and oxidization and creation of air bubbles are, it is contended, by this new method of smelting in a vacuum, by means of removal of carbonic acid gas, etc., also avoided. The metal becomes more liquefied and, on account of the casting forms being denuded of air, permits of extremely close and fine casting, even of objects of excessively small diameters. Among other pertinent justifications for these assumptions is the fact that the samples which have up to the present been tested in the proof rooms of the Royal Technical School at Charlottenburg, near Berlin, have, notwithstanding the prejudicial circumstances under which they have been produced, according to a copy of the Government report in regard to such tests, shown very satisfactory results. From the nature of the system adopted it ensues that the electric force which is carried out with currents of great strength, but low voltage, is attended with absolute freedom from danger. Small iron propellers and similar objects are constantly melted and cast at Bahrenfeld in the presence of witnesses within a period of 12 to 15 minutes. Currents of 20,000 to 30,000 amperes are no exaggeration, and exhaustion of air from the largest chambers now presents no difficulty. By the employment of 30,000 amperes and 50 volts, a force equivalent to about 2,000 H.P., or somewhat less than that used by the aluminium works at Neuhausen, on the Rhine, the casting form would have a minimum length of 12 meters, and a width of 1½ meters. This would give a body of metal of 180,000 cubic centimeters, or about 1½ tons. According to the experience gained in experiments at Bahrenfeld, such casting would be effected in one process lasting in all not longer than a quarter of an hour. The expenditure of coal is, therefore, in round figures but 50 per cent. of that necessitated by the most perfect system at present in use. The use of water power naturally increases these advantages in an enormous extent.

The iron furnace seen by Mr. Pogson at Professor Taussig's works at Bahrenfeld consisted of a rectangular vessel 6 ft. × 3 ft. × 3 ft. Two electrodes, apparently of wrought iron, were placed upright inside the furnace, so that their surface of 8 in. × 4 in. faced the arc-shaped piece of iron which was to be fused; a channel of clay served the purpose of conducting the fused metal from its clay melting bed into the empty clay mold of a model propeller, the mold in question being placed at a lower altitude in the otherwise empty iron furnace. The wires connecting the flat metal electrodes with the powerful generating machinery put up by Messrs. Schuchert & Company, the well-known German electrical engineers, were already in position, as was also the exhaust-pipe connecting the furnace with a steam air-pump of about 20 H.P., which also drove the dynamos. Having personally placed the 30 lbs. of pig iron in the clay bed, placed parallel with, but a few inches in front of, the flat electrodes, the cover of the oven was swung on; the necessary exclusion of external air being effected by India-rubber pads fastened to the furnace cover. Punctually at noon the cover was fastened down, and the pump set working, the current being switched on at the same moment. The indicator of the exhaust-pump soon showed an exhaustion of 92 per cent. of air. The electric indicators showed respectively 2,500 to 3,000 amperes and 2 to 2½ volts. The gradual approach from red to white heat could be followed from the eyelets in the furnace. Fusion was obtained at about 12.8, the indicators showing great unsteadiness until the resistance had been reduced to *nil* by the current being allowed to pass freely through the fused metal. At 12.14 the furnace was opened, and a minute or two later the clay was being chipped off, and the perfect cast of a propeller was exposed to view.—*Sheffield Telegraph.*

UNION-PASSENGER STATION, PORTLAND, ME.




GROUND PLAN OF UNION PASSENGER STATION, AT PORTLAND, ME.

## UNION PASSENGER STATION AT PORTLAND, ME.

We give herewith a full-page perspective illustration and a general ground plan of a new union station which has been recently built at Portland, Me., under the supervision of Messrs. Winslow & Wetherel, architects. The general appearance and arrangement will be readily understood from the examination of our engravings. The exterior is built of Conway pink granite, the roof being of light-green slates. The interior is richly and simply finished in hard wood. In the general waiting-room there are two handsomely carved stone fireplaces, which may be regarded as the principal feature of the interior. The building is heated by steam, lighted by electricity, and its details comprise every modern improvement and luxury known to the present time. We are indebted to the *American Architect and Builder* for the perspective and to the architects of the building for the plan.

## PROGRESS IN FLYING MACHINES.

By O. Chanute, C.E.

(*Continued from page* 138.)

In July, 1880, M. *Biot* exhibited to the French Society for Aerial Navigation an ingenious kite, invented by himself, which sailed without a tail and possessed great stability under all conditions of wind.

At the top of a flat plane of elongated elliptical shape two hollow cones were affixed, one on each side. The base or large end of these cones faced the wind, and the other end or point was slightly truncated, so as to leave an opening through which the wind could blow, and, by the action of the streams or columns of compressed air thus created, counteract any tendency of the plane to tip to one side or to the other. This provided for the lateral stability on the same principle as in the well-known Japanese kite, in which the side-pockets catch the wind and maintain the equipoise.

The fore and aft equilibrium was provided for by affixing a rotating screw at the lower end of the plane, pivoted on its central line. This screw had two vanes of coarse pitch, and was free to rotate under the impulse received from the wind. It spun around with great speed when the kite was raised, and obviated any need of the usual tail by performing the same steadying office. It prevented any oscillations, without impeding the rising of the kite, and maintained it perfectly steady in all winds.

It was not agreed between the French aviators whether this effect was due to the action of the vanes, making an angle with the sustaining plane, as in the case of *Pénaud's* "planophore," or to "gyroscopic" action, but when the screw was omitted the kite swayed about, while when the screw was rotating, its twirling and tremor could be felt through half a mile of string, and the kite remained perfectly upright and steady.

M. *Biot* carried on quite a series of experiments with this apparatus. In the kite which he used the elliptical plane was 15 in. high, the two cones at the side were each 8 in. in diameter at the base by a height of 8 in., while the screw was 12 in. in diameter, its two vanes being each 1⅝ in. broad.

The experiments were carried on in winds varying from 13 to 33 miles per hour, and the kite was found to be steady under all conditions, the only difference being in the height to which it would rise. When the wind blew from 13 to 18 miles per hour, 4,900 ft. of cord were paid out, the kite remaining at this distance during two hours. On other occasions, with stronger wind, as much as 6,500 and 8,200 lineal feet of cord were paid out, and the kite mounted so high that it passed through several strata or currents of wind of varying direction, as was conclusively proved by the fact that the restraining cord assumed a sinuous attitude when the full height was gained, and instead of approximating to a straight line or a regular curve, as usual, the line became serpentine in form, thus indicating that different trends existed in the various strata of air.

In one instance the kite, with 2,600 ft. of cord paid out, advanced against the wind and mounted directly over the head of the operator. This was attributed to an ascending trend in the wind, for the kite still tended to rise vertically and to advance against the wind, although the plane was

horizontal, and the cord, now greatly bowed by the wind, tended to drag the apparatus backward. This attitude continued but a short time, when, the trend of the wind having apparently changed, the kite settled back to its original position, flying at an angle of 40° to 60° with the horizon.

M. *Biot*, who was an old experimenter with kites (having as early as 1868 been lifted up from the ground by a large apparatus of this kind), found the gyroscopic stability of the arrangement which has just been described so satisfactory, that he thereupon designed, in connection with M. *Dandrieux*, a full-sized aeroplane on the same principle, calculated to carry up a man. This design was submitted early in 1881 to a special committee of the French Society for Aerial Navigation, but this committee seems to have hesitated in recommending its construction, and no record has been found by the writer of its having been built or experimented with about that time.

When, however, the publication and discussion of M. *Mouillard's* "L'Empire de l'Air" had directed fresh attention to the soaring of birds on rigid wings, and given grounds for the belief that man could utilize the wind in the same way, M. *Biot* constructed in 1887 a soaring apparatus in the shape of an artificial bird 27 ft. across, and weighing 55 lbs., with which he hoped to reproduce the manœuvres of the sailing birds.

It is known that a number of very interesting experiments were tried with this apparatus, but the writer has been quite unable to find in print, or to obtain from correspondents, a description of the machine or a record of its trials. He merely knows that these trials were many, and that on one occasion M. *Biot* suffered a tumble which was not encouraging to further experiment, but no account of them is to be found in the *Aéronaute.*

It is to be hoped that a full narrative may yet be given to the public of the results of experiments which must have been most instructive for other aviators who contemplate imitating the birds.

In 1882 M. *Jobert* exhibited before the French Society for Aerial Navigation the model of a proposed apparatus designed by himself, in order to test the possibility of imitating the manœuvres of the soaring birds, as described by M. *Mouillard.* This aeroplane was to be hinged and jointed, so that it might be folded up like an umbrella for convenience in transportation, or opened out and stiffened by sliding bars in order to make the wings rigid. With this M. *Jobert* proposed to experiment on various areas of surfaces in proportion to the weight, and to test the efficacy of both fixed and adjustable sustaining surfaces. He does not seem to have met sufficient encouragement to carry out his design, for the writer has been quite unable to learn that he ever completed a full-sized aeroplane capable of sustaining a man.

Having begun where M. *Biot* terminated—*i.e.*, with the design for a soaring apparatus—M. *Jobert* next turned his attention to kites, and proposed in 1887 the apparatus shown in fig. 67, which he termed a "rope-bearing kite," designed for establishing communication with wrecked vessels. It consisted of a hollow truncated cone *C*, under which was rigidly connected a kite *P*, from which depended two light lines terminating in a ring, the latter carrying a light cord steadied by the drag *D*. The object of this arrangement was to ensure a rapid and certain connection with the shipwrecked mariners, who, by seizing the light cord, could at once haul down the kite and thus gain access to the main carrying rope, with which to haul aboard the usual life-saving cable. This carrying rope was fastened to a bridle attached to the top cross-stick of the kite, and to the top of the cone at *V*, which arrangement was claimed to produce perfect stability, and to ensure that the apparatus should travel straight back in the line of the wind without rising to any great elevation. In order to regulate the height, the angle of the plane could be varied by means of a light string (not shown), extending from the lower cross-stick to the carrying rope and fastened by a hook in one of a series of loops.

The sustaining plane was, like the cone, formed of calico, in which hems were turned at the top and at the two sides, in order to form cases for the sticks of the frame, the lower edge of the kite being left uncased, in order to produce bagging and consequent increase of lifting power. At the small end of the cone a couple of thin metallic tongues were fastened, which, thrown into vibration by the wind rushing through the cone, produced a howling sound which might notify the shipwrecked sailors of the approach of the apparatus, and the whole arrangement, as will readily be perceived, was quite cheap and readily rigged up or folded away, no matter how large it might be.

The writer does not know whether this apparatus ever came into practical use. It has here been figured in order to show how a cone can be applied to a kite in order to impart stability to the latter, but the arrangement would need to be greatly modified in order to admit of its utilization in an aeroplane, so as not unduly to increase the resistance to forward motion.

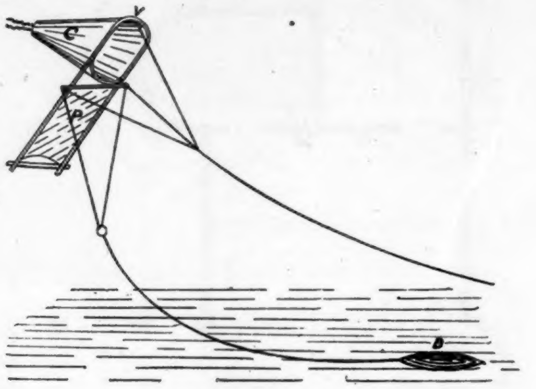



FIG. 67.—JOBERT—1887.

In 1886 and 1887 M. *Maillot*, a French rope-maker, tried quite a series of experiments with the kite represented in fig. 68. This was constructed of poles and canvas, in the shape of a regular octagon; it measured 775 sq. ft. in area, about 32 ft. across, and weighed 165 lbs. It had neither balancing head nor tail, and was so poised by the bridle of attachment that the center of pull corresponded to a point only one-third of the distance back from the front edge, or to a spot, therefore, decidedly forward of the center of pressure, at the comparatively coarse angles (30° to 60°) usually assumed by kites. This angle of incidence it was intended to regulate by a cord, attached to the rear edge and carried to the seat swung beneath the kite for the operator, who might then, by hauling in or paying out this cord, regulate the angle of incidence and cause the kite to rise or to fall. This was intended to furnish the longitudinal stability, while (there being no provision for automatic lateral equilibrium) the side oscillations caused by the varying intensity and directions of the wind were restrained by side ropes attached to the kite and handled by men standing on the ground.

In the first experiments (May, 1886) M. *Maillot* was dissuaded from ascending beneath the kite, and he therefore substituted for his person a bag of ballast weighing 150 lbs., tied just below the seat. The kite was raised by first securely anchoring the main rope, which was 800 ft. long, and then lifting up the front edge so that the wind might sweep under the surface, upon which the kite rose to such height that the bag of ballast swung some 30 ft. above the ground, where M. *Maillot* and two assistants managed the two side ropes and the tail cord (not shown in the figure), which latter regulated the angle of incidence by depressing or raising the rear of the kite.

Allowing 33 lbs. for half the weight of the main rope, it was estimated that the apparatus sustained, on this occasion, an aggregate weight of 348 lbs., or in the proportion of 2.23 sq. ft. per pound. The wind was variously estimated at 15 to 22 miles per hour; but as this speed was not measured, nor the pull upon the various ropes ascertained, while the angle of maximum incidence was merely guessed at as about 45°, no accurate computation can be made of the various reactions. The kite was easily controlled by the three men, hauling or paying out the two side ropes and the tail cord, but it plunged about with the varying intensity of the wind, and in one of the oscillations so produced the bag of ballast was whipped about and broke the rope by which it was suspended.

M. *Maillot* repeatedly experimented with this and other kites (but smaller) on the same principle during the year 1887. He states that he succeeded in sustaining as much as 594 lbs., but whether he ever went up himself beneath the kite the writer has been unable to ascertain. There would have been little or no risk in doing so, provided the wind was steady and strong, for it is evident that the three lines carried to the ground would give almost complete command over the apparatus, but then such a performance would have taught very little toward the management of an aeroplane free in the air. Changes were made from time to time in the modes and points of attachment of the various ropes, and the endeavor seems to have been directed to the discovery of some arrangement by which automatic equilibrium could be secured under all conditions and varying velocities of wind without the use of a tail. From the discontinuance of the experiments it is inferred that they did not succeed, and the writer attributes this failure (if failure it was) to the employment of a *single* rigid *plane;* for it will be remembered that M. *Pénaud* obtained a stable kite, on the principle of his "planophore," by adding to the upper pair of planes a second set, inclined at a slight angle to the first, the effect of which was to regulate the incidence.

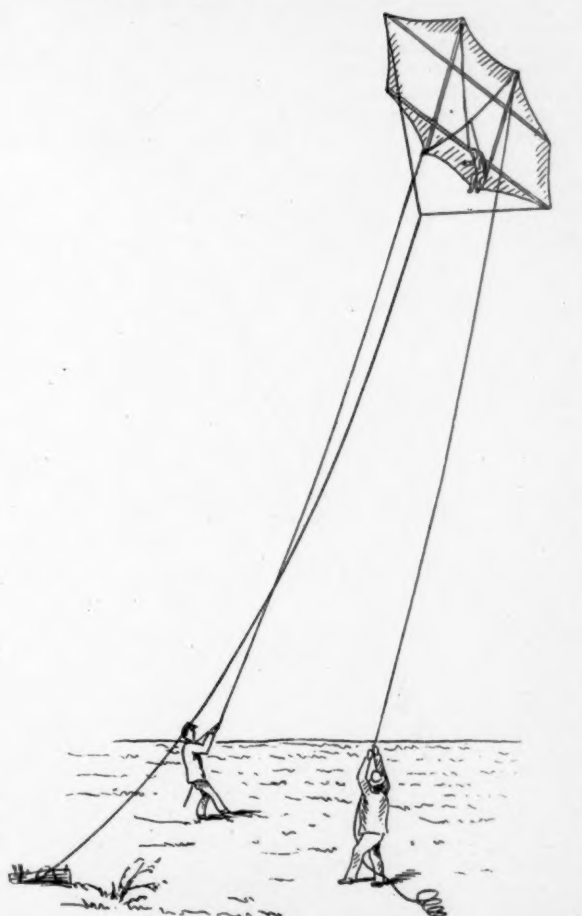


FIG. 68.—MAILLOT—1887.

On the same principle, M. *Barnett*, whose proposed aeroplane has already been noticed, obtained stability with a tailless kite many years ago, by shaping the plane like a laundry "flat-iron," cutting out a portion of this from the rear or broad end, and adjusting the band so obtained at an angle with the rest of the surface, so that the kite would fly steadily.

M. *Copie*, on the other hand, obtained partly the same effect by inserting a hemispherical pocket in the body of the kite, but this did not prove quite satisfactory until an opening was cut in the apex, on the same principle as the hole which is provided in the top of a parachute, after which the wind, rushing through the pocket, produced much the same effect as in the *Jobert* regulating cone; but the device is not one which can be profitably applied to an aeroplane in forward motion.

Upon the whole, M. *Maillot's* kite was rather crude, and decidedly inferior to *Pocock's* "charvolant," heretofore described, in which the pilot kite might be used to regulate the carrying kite. The stability of the *Maillot* arrangement could probably have been improved, and the side ropes dispensed with, by breaking up the surface into two planes, forming a diedral angle with each other, like the attitude of a bird gliding downward, or the same effect might have been partially produced by providing the plane with a keel.

Very good results with central keels have been obtained by M. *Boynton* with his various forms of "Fin" kites, which are now sold in the shops. They consist of a plane, to which is affixed at right angles a "fin" or keel located in the lower part of the kite, and raised slightly above its surface. They fly without a tail, with a steadiness depending somewhat upon the form of the main bearing surface, and seem to afford a good opportunity for further experiment as to the shape of greatest stability; for keels have been frequently proposed for aeroplanes, in which they will produce less resistance to forward motion than obtains with other arrangements, but few seem to have tested how such keels should be applied.

These remarks chiefly apply to *plane* rigid kites, and to the various adjuncts and forms which have been tried in order to confer stability upon a main plane surface sustaining the weight; but still better results have been obtained with flexible surfaces, and it seems not improbable that this is the arrangement which will give the greatest amount of stability to a kite, by producing automatic adjustment to the wind's varying intensity.

As an example of such action may be mentioned the "Bi-Polar" kite of M. *Bazin*, who experimented with it in 1888. It consists of a main sustaining surface like a boy's "bow" kite, or practically the same in shape as the kite surface in fig. 66. The frame is composed of two sticks, one of them a flexible rod at the head, bent to a bow, and the other a main central spine at right angles, to which the bow-strings are fastened. The peculiarity of the "Bi-Polar" kite is that this central spine is also made flexible, and that to its lower end (projecting some distance below the supporting surface of the kite) three triangular fins are attached, just like the tail of a dart, omitting one fin. This arrangement obviates any necessity for a tail and confers automatic stability, for the lateral equilibrium is obtained through the elasticity sideways of the main surface or head, which is blown back by the pressure to a convex surface with a diedral angle, which angle varies in accordance to the violence of the wind, while the longitudinal equipoise is likewise maintained by the balancing pressures on the head and on the fins, as the flexible spine yields more or less to the breeze. The kite is thus made stable in both directions, and flies steadily without a balancing tail. M. *Bazin* sailed it with two strings, one attached at the top and the other at the bottom of the main sustaining surface; these strings were both carried to the ground, and attached at each end of a stick of equal length with the vertical distance which they spanned at the kite, and with this stick in his hand the operator could vary the angle of incidence. This was intended to secure measurements of this angle of incidence in connection with the pull, but the results thus obtained have not as yet, to the writer's knowledge, been published.

Even better results can be attained with the "Malay" kite, which is in shape a lozenge, composed of two flexible sticks crossing each other at right angles. The cross or horizontal stick is the longest, being preferably 1.14 times the length of the upright stick, and fastened to the latter at a point 0.18 of its length below the top; a string is then carried (in notches at the ends of the sticks) around the periphery of the resulting lozenge, and this is covered with paper or with muslin in the usual way. This surface, when impinged upon by the wind and restrained by the bridle, is bent back by the pressure and adjusts itself to the varying irregularities of the breeze, the kite flying without a tail with great steadiness and rising to great elevations.

M. *Eddy*, of Bayonne, N. J., who has been constantly experimenting with kites during the last few years, and who is recognized as an expert in such matters, prefers the "Malay" kite to all others. He has improved it by so fastening the cross-stick and tying its outer ends as to

produce a slight initial convexity, which is further increased by the action of the wind, and which materially adds to the steadiness of the flight. With this arrangement M. *Eddy* has succeeded in causing a single kite to ascend to a height of 2,400 ft. with 3,000 ft. of line, and then bringing it to the zenith directly over his head, or even a little back of his hand, where its attitude strongly suggested the advance of the soaring bird against the wind. Upon a previous occasion he had succeeded in attaining a height of 4,000 ft., with a string of five kites flying in "tandem"—that is to say, each kite attached by a string of its own to the string of the preceding kite already raised, so as to take up the slack or sagging of the line, and thus enable the upper kite to rise to an altitude otherwise unattainable. This performance seems to suggest an easy way for the exploration of the upper air by the Weather Bureau, for by affixing to the upper kite self-registering instruments (thermometer, barometer, hygrometer, etc.), or, preferably, by connecting such instruments (and an anemometer besides) electrically with recording instruments on the ground (through a series of fine wires insulated in the kite string), observations of the conditions prevailing aloft can be easily obtained. The French have lately been making such observations by means of "free balloons" of medium size, and they are said to be of material assistance in forecasting the weather; the records obtained from the top of the Eiffel Tower showing that even at that moderate height coming changes in wind and in temperature are indicated several hours in advance of their prevalence at the ground.

The same principle of obtaining stability without a tail, by means of an elastic frame, can be applied to other forms than the "Malay" or the "Bi-Polar" kites, but it requires a good deal of delicate adjustment and balancing. It has been done with the common octagonal form of kite by M. *C. E. Myers*, of Frankfort, N. Y., the aeronautical engineer who furnished and operated the balloons and kites by means of which the recent (1891) rain-compelling experiments were tried in Texas.

It will be remembered that the explosions intended to produce rain were in some cases produced by exploding dynamite suspended below kites, and fired by electricity. In providing for this, M. *Myers*, who has for several years been conducting systematic experiments with kites, evolved some very interesting facts, and he has published part of his experience in the *Scientific American Supplement* (No. 835) for January 2, 1892, from which the following is extracted:

The originating cause of my interest in kite-flying is aerial navigation, and by successive steps I have adapted kites to fly without tails, to fly with considerable weight attached, and, finally, to fly without the restraint of the usual kite-string; and, rising higher and higher, finally to disappear miles in height and miles away on the verge of the distant horizon.

Theoretically, there should be no difficulty in attaining these results. Practically, there is as much difficulty as with a child learning to walk or a youth learning to manage a bicycle. In a word, it is the art of balancing. . . .

Theoretically, the kite should be light or possess much surface with little comparative weight. It should balance at the flattest possible angle, nearly horizontal, and its surface should be widespread, like the wings of a soaring bird. As a fact, I have obtained the best results with this model, but had great difficulty at first to induce it to fly at all, and was finally forced to attach a compromise tail—not a kite tail, but a bird-like tail, which, being flexible, vibrated or undulated with the vertical oscillations of the kite, and thus acted as a propeller, so that this kite actually moved against the wind. . . .

The most practical form of kite for general purposes seems, however, to be the six-sided. Those created by me as part of my apparatus for the Government rainfall expedition in Texas were composed of an X, formed of two spruce sticks, each 6 ft. long, tapering, with a top section of $\frac{1}{4}$ in. $\times$ $\frac{1}{4}$ in. and bottom section of $\frac{1}{2}$ in. $\times$ $\frac{1}{2}$ in. tacked flatwise together with a very small pin-nail, and bound with hemp cord at the joining. Five in. below this crossing (which was about 2 ft. from the top) was a similar piece of timber, but 14 in. shorter, and tapering each way, placed crosswise of the X, horizontally, so as to form a 5-in. triangle, which stiffened the frame more than if all crossed at one point. The outer end of each stick was creased with a knife and notched around, so that a hemp cord passed first through the crease and was "half-hitched" around each stick to prevent splitting. The kites were covered with red calico, pasted on tight, and bits of cloth were also pasted across the sticks where the kites-trings attached. These strings were attached as long loops—one loop to the top sticks about 6 in. from their tips, one loop to the two bottom sticks about 30 in. from the bottom, and one loop to the cross-bar about a foot from each end. All these loops were then gathered together and drawn through one hand as the kite lay on the ground, held in place by one foot on its crossing, and being adjusted carefully and equally to draw from *a point somewhere midway between the cross-stick and top*, best attained by trial, were then tied together.

The kite was thus rather stiff and light at top, *elastic* and heavier at the bottom, and suspended at a point *above* its center of gravity and center of surface. To the loop at the bottom was usually hung a narrow strip of cloth to afford greater steadiness in supporting the kite's burden of dynamite to be exploded. I have been thus particular to describe minutely this construction because many have written me for this information.

The first trial kite flown at Midland, Tex., escaped. I had built it all myself, as a model, and it had drawn up one ball of hemp twine, and an assistant was holding the string preparatory to running out another ball when the cord parted at a flaw, and the kite flew into space. When last seen with a glass, it was estimated to be about 3 miles high and 8 or 10 miles away, a fading red dot in the distance. . . .

In ordinary light winds this kite floats well, is steadier than many other kinds I have tried, and would seem to be well adapted for photography. If hung very near its top, it is prone to advance upward and forward against the wind, till over and beyond the party holding the string, and literally floats on the air as if propelled by its fluttering triangular section at or near the bottom of the kite.

The accidental escape of this kite exhibited a very interesting example of partial "aspiration," and it is understood from additional information, kindly furnished by M. *Myers*, that he succeeded in reproducing this effect on several occasions. The kites were hung, after considerable experiment, so that they floated nearly flat on the air, with as little tail as possible, and sometimes none at all. They rose upon a light breeze, and drew away as long as the string was let out. When checked or pulled, they rose higher and higher until quite overhead, when the string had to be released. If suitably balanced the kite then rose still higher and drifted back, *but not as fast as the wind blew*, its rearward flap vibrating more or less, and *making its action a progressive one relative to the wind*, thus producing "aspiration" with respect to the breeze. A long string, or small weight at the end of a shorter string, was sufficient to keep it balanced, so that it might remain up for hours and go floating out of sight.

The possibility of this progressive action against the wind without loss of height or of "aspiration" has been strenuously denied, and yet it is easily explained if, instead of assuming the wind to blow horizontally, as we generally do, we consider that it has at times a more or less ascending trend, this being a not unusual condition over the sun-broiled plains of Texas. It is clear, from the description of the mode of attachment of the string, that its weight when released would tilt the kite forward, so that the plane would point below instead of above the horizon. In this position the direction in which the "drift" is exerted would be reversed—that is to say, the horizontal component of the pressure, instead of pushing backward, would be pulling forward, and thus *become a propelling force against the wind*, provided, of course, that the latter still exerted its pressure on the *under side* of the kite. Thus an upward trend in the breeze of but 3° or 5°, operating against a kite inclined forward 2° below the horizon, would be sufficient to cause it to advance relatively to the wind, somewhat as a vessel "close hauled" advances against the breeze which furnishes it motive power. In point of fact, therefore, that which has herein been termed the "drift" may act upon a *plane* surface, as a force pushing backward or propelling forward, according as that *plane* is inclined to the front *above or below the horizon*; but in the latter case there needs be an ascending trend in the wind in order to produce a sustaining pressure on the under side, for otherwise the horizontal wind would strike the upper surface of the *plane* and press it downward instead of upward. The effect may be quite otherwise with concavo-convex surfaces.

(TO BE CONTINUED.)

## RESISTANCE OF METALS TO SHEAR.*

By H. V. Loss, M.E.

(*Continued from page 182.*)

### APPENDIX.

In reviewing the results of the experiments, we find that in some instances new facts are developed; in others, that the present ideas are corroborated and their details specified, while again in some cases the results appear to contradict hitherto prevailing assertions.

In regard to this latter fact, a few words may be said in explanation.

John W. Nystrom gives, in his "Pocket-Book of Mechanics," a formula for the necessary power to cut any iron bar of a thickness $t$—given in number of sixteenths of an inch—with a knife of a given bevel, $a$:

$$P = O .88\ t^2\ cot.\ a.$$

That this is erroneous will easily be seen when assuming $a = O$, in which case $P = \infty$. Besides, the formula does not contain the width of bar, which element, as seen from plate No. 6, will always make itself felt up to a certain limit, depending upon $t$ and $a$.

Clark gives in his "Manual," on page 587, some results of experiments on iron bars with flat knives. The width was 3 in. and the thicknesses were ½ in. and 1 in. The resulting figures show a small difference in ultimate pressure per square inch for the two thicknesses, or, in other words, the maximum resistance per inch of width was not in proportion to the thickness of the bar—a result which is not confirmed by plate No. 10. However, the experiments were so few and limited—being only made with one width of bar and two thicknesses—that they would form but a meager guide as to any general doctrine that may be said to govern the shearing of metals.

In order to throw some additional light upon this subject, the writer devoted some little time to such experiments and analysis that would explain the action of the shear blades during their penetration of the bar.

It is not the idea of the writer at the present time to give an exhaustive theoretical analysis of the subject, but rather to indicate the lines upon which such an analysis can be made, and to emphasize the fact that the theory of flexure is mainly if not solely the correct theory of shear as existing with practical shearing machinery.

The following calculations were made with this in view, and as an example the shearing power for rectangular bars has been deduced with flat knives. The writer has likewise computed some of the data and elements necessary for the analysis of shear with inclined knives, all based upon the application of the theory of flexure.

If practical shearing means flexure, why does the ultimate resistance, when using flat knives, simply depend upon the thickness of bar in $1^{\text{th}}$ power?

Some experiments were made with the view of finding the leverage of pressure existing at the point of maximum resistance, or at a period when the hydraulic force $P$ was of a known quantity. They were conducted on soft steel, and the progress of knives was arrested either by stalling the hydraulic ram or by reversing the valve lever immediately the first "break" occurred. A beveled knife—8°—was used, as with a flat knife the point of maximum resistance is too close to the point of final rupture to allow the stoppage of the blades, if accomplished by the lever, to take place with any accuracy. The mark left on the top surface of the bar, as having been in contact with the underside of top knife, was precisely and invariably a duplicate of the one left on the under side of the bar, as having been in contact with the top side of the bottom knife. These marks were of a triangular form, and the table, No. 7, gives the values of the letters on fig. 3 as found from the experiments with the different sizes.

TABLE NO. 7.

| $w$ | $t$ | $r$ | $s_1$ | Remarks. |
|---|---|---|---|---|
| 5" | 1⅛" | 4⅝" | ⅝" | Broke. |
| 6" | 1⅜" | 4⅜" | $\frac{13}{16}$" | Broke. |
| 6" | 2¼" | 3½" | 1¼" | Stalled. |
| 7" | 2" | 4⅝" | $1\frac{1}{16}$" | Stalled. |

* The articles in this series which have preceded this have all been copyrighted; the note to that effect was, through an oversight, omitted.

The two last bars on the table did not break, the knives being stalled at a total pressure of 330,000 lbs.

Comparing the values of $s_1$ and $t$, we observe a close relationship to exist between these two dimensions; thus we find:

TABLE NO. 8.

| $w =$ | 5" | 6" | 6" | 7" |
|---|---|---|---|---|
| $s_1 =$ | $.55\ t$ | $.59\ t$ | $.55\ t$ | $.53\ t$ |

As an average result we have

$$s_1 = .55\ t. \tag{4}$$

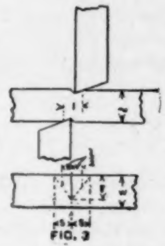


FIG. 3

The total shearing power $P$ is distributed on the triangular surface, the dimensions of which are $r$ and $s_1$.

With a view of determining this distribution in order to find the position of the center of pressure, let $d_1$, fig. 4, represent the depth of cut or compression at the edge relating to the dimension $r$ and $s_1$.

At a distance $s$, the differential area of bearing surface is

$$\delta\,\Delta = r\left(\delta\,s - \frac{1}{s_1}\,s\,\delta\,s\right) \tag{a}$$

If $p_1$ = pressure per square inch of surface at the edge, corresponding to the distortion $d_1$, let $p$ represent the pressure at $d$. We have:

$$p : p_1 = s_1 - s : s_1, \text{ or}$$

$$p = p_1\left(1 - \frac{s}{s_1}\right) \tag{b}$$

But this pressure, $p$, reaches the intensity as expressed by equation ($b$) only at the edge, decreasing directly with the distance inward, and finally becoming zero. Its average value on the differential surface is

$$\tfrac{1}{2}\,p_1\left(1 - \frac{s}{s_1}\right)$$

Multiplying this expression by equation ($a$), and integrating between $S_1$ and $O$, the result will equal $P$. Thus

$$P = \int_O^{s_1} \tfrac{1}{2}\,p_1\left(1 - \frac{s}{s_1}\right) r\,\delta\,s\left(1 - \frac{s}{s_1}\right) = \tfrac{1}{2}\,p_1\,r \int_s^{s_1}\left[\delta\,s - \frac{2}{s_1}\,s\,\delta\,s + \frac{1}{s_1^2}\,s^2\,\delta\,s\right]$$

$$= \tfrac{1}{2}\,p_1\,r\left[s_1 - \frac{2}{s_1}\,\frac{s_1^2}{2} + \frac{1}{s_1^2}\,\frac{s_1^3}{3}\right] = \tfrac{1}{2}\,p_1\,r\,\tfrac{1}{3}\,s_1$$

$$P = \tfrac{1}{6}\,p_1\,r\,s_1, \text{ or}$$

$$p_1 = \frac{6\,P}{r\,s_1} \tag{5}$$

Inserting (5) in equation ($b$) we have

$$p = \frac{6\,P}{r\,s_1}\left(1 - \frac{s}{s_1}\right) \tag{c}$$

In order to find the moment of the pressure on the surface $\delta\,\Delta$ about the line $X - X$, we have

$$\delta\,Mm = \tfrac{1}{2}\,p.\ \delta\,\Delta.\ s = \frac{3\,P}{r\,s_1}\left(1 - \frac{s}{s_1}\right) r\,\delta\,s\left(1 - \frac{s}{s_1}\right) s$$

$$\delta\,Mm = \frac{3\,P}{s_1}\left(1 - \frac{s}{s_1}\right)^2 s\,\delta\,s, \text{ and}$$

$$Mm = \frac{3\,P}{s_1}\int_O^{s_1}\left(1 - \frac{s}{s_1}\right)^2 s\,\delta\,s = \frac{3\,P}{s_1}\int_O^{s_1}\left[s\,\delta\,s - \frac{2}{s_1}\,s^2\,\delta\,s + \frac{1}{s_1^2}\,s^3\,\delta\,s\right]$$

$$= \frac{3\,P}{s_1}\left[\frac{s_1^2}{2} - \frac{2}{s_1}\,\frac{s_1^3}{3} + \frac{1}{s_1^2}\,\frac{s_1^4}{4}\right] = \frac{3\,P}{s_1}\,\frac{s_1^2}{12}$$

$$Mm = \tfrac{1}{4}\,P\,s_1 \tag{6}$$

The distance from the center of pressure to line $X - X$ is now

$$\frac{l}{2} = \frac{Mm}{P} = \frac{\tfrac{1}{4}\,P\,s_1}{P} = \tfrac{1}{4}\,s_1$$

The total leverage with which the force $P$ causes a moment of flexure is now

$$l = \tfrac{1}{2}\, s_1 = \tfrac{1}{2}\, \tfrac{5}{9}\, t = \tfrac{5}{18}\, t \qquad (d)$$

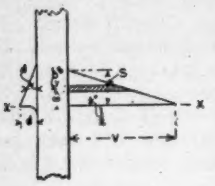


FIG. 4

We can assume the same leverage to exist with flat knives, in which case the triangle of bearing surface becomes a rectangle. This assumption is in accordance with the idea of a flat knife having a bevel, $a$, the value of which is infinite small, in which case the angle between the hypotheneuse in the triangle and line $X - X$ becomes infinite small as well, or practically speaking, zero.

In this case, we have for the bending moment

$$Mm = P\, \tfrac{5}{18}\, t = w \frac{t^2}{6}\, f,$$

where $f$ denotes the tensile strength of the material. Continuing,

$$P = \frac{18}{5 \times 6} \frac{w\, t^2}{t}\, f = \tfrac{3}{5}\, w\, t\, f = \tfrac{3}{5}\, A\, f \qquad (7)$$

Thus we see that while bending really *does* occur, the thickness of bar, nevertheless, exists only in 1th power. Considering the cross-area of the bar $A$, we find the ultimate shearing power to be the product of this area and three-fifths of its tensile strength. Equation (7) gives the theoretical explanation why only a certain fraction of the tensile resistance is "the apparent coefficient of strength" of a bar when exposed to shearing. The writer fully believes that this is a feature rarely understood.

The general opinion is undoubtedly that all square inches do equal work, but that each one possesses a strength or resistance which represents only a certain percentage of the tensile strength of the material. To be sure, there is a direct shear as well, but this stress is under 90° with the former, and the bar will break before the latter has reached its ultimate.

Comparing equation (7) with plate No. (10), we have for a bar 1″ wide × $1\tfrac{1}{16}$″ thick, the result by diagram to be 50,000 lbs.

Equation (7) gives for the same dimensions, when considering 75,000 lbs. steel,

$$P = \tfrac{3}{5}\, 1.0625\ 75000 = 48000 \text{ lbs.}$$

In examining plate No. (12), giving the ultimate pressures for angles, it is clearly seen that the thickness of leg $t$ enters any possible equation for $P$ in a power less than 1. Assuming a parabolic expression:

$$P_1 = K \sqrt{t} \qquad (e)$$

Plate (12) is satisfied by having $K = 38000$, or

$$P_1 = 38000\ \sqrt{t} \qquad (f)$$

or for the total width of angle its legs being $a$ and $b$.

$$P \doteq 38000\, (a + b) \sqrt{t} \qquad (8)$$

Comparing equations (7) and (8), it may be possible to derive from the former expression a general formula for angles, based upon the principles used in the analyses in equation (7). With the form of die here used, $t$ will become $\sqrt{2}\, t$, while the total width is diminished in the same ratio. Assuming the new thickness in the power of $\tfrac{1}{2}$, and inserting $\frac{a + b}{\sqrt{2}}$ instead of $w$, we have

$$P = \tfrac{3}{5} f \frac{a + b}{\sqrt{2}} \left( \sqrt{2}\, t \right)^{\frac{1}{2}} = \tfrac{3}{5} f \frac{a + b}{\sqrt{2}} \sqrt{t} = \tfrac{3}{7} f\, (a + b)\ \sqrt{t} \qquad (9)$$

If the above assumptions are correct, then

$$\tfrac{3}{7}\, f = 38000, \text{ or}$$
$$f = \tfrac{7}{3}\ 38000 = 85000 \text{ lbs. per square inch,}$$

as the ultimate tensile strength of the steel. This figure corresponds fairly well with the ultimate mentioned for steel angles, running up to 80,000 lbs.

When applying formula (9) to iron angles, inserting $f = 50000$, the results will invariably be too small. A value of $f = 65{,}000$ will give the desired results with fair accuracy. This is in harmony with the statement made in the earlier part of this paper, that the ratio between the shearing ultimates of iron and steel is not the same as the one acquired by tension in the testing machine.

Does this mean that with iron, and slightly also with steel, the coefficient of *ultimate transverse* strength is quite different from the coefficient of *ultimate tensile* strength?

With inclined knives the most intense pressure exists on the fibers at the edge first touched by the knife. The first break also occurs here.

Equation (5) gives an idea of the great numerical value of the stress at this point. The product of $r$ and $s_1$ becomes so small for light bars as to cause a rate of pressure at this edge far above $P$ itself.

The width of bar will enter any expression for the ultimate shearing resistance when using inclined knives. Plate No. 6 shows this fact most clearly. But this same plate also indicates the limit, where $w$ disappears. Judging from the two thicknesses there shown, it would appear that a parabolic equation would express the limiting value of $w$ with fair exactness, or

$$w = \sqrt{p\, t} \qquad (g)$$

Insert here $t = 1\tfrac{1}{8}$″ and assume $w = 7$″, being practically the limit, as shown on diagram, we find

$$p = \frac{w^2}{t} = \frac{49}{1\tfrac{1}{8}} = 43.5, \text{ and}$$

$$w = \sqrt{43.5\, t} = 6.6\ \sqrt{t} \qquad (10)$$

With $t = 1\tfrac{5}{8}$″, we find $w = 8\tfrac{3}{8}$″, which agrees very well with the experimental results, as shown on plate No. 6.

When examining plate No. (11) we find the experimental records of the energy necessary to shear rectangular steel bars with flat knives to correspond very closely to the conic expression:

$$E = 1100\, w\, t^2, \qquad (11)$$

$E$ being the energy required in foot pounds.

This same equation can also be applied to steel angles, when remembering that the form of die used changes $t$ into $\sqrt{2}\, t$. Denoting the length of legs by $a$ and $b$, we have

$$E = 1100 \left(\frac{a + b}{\sqrt{2}}\right) \left( \sqrt{2}\ t \right)^2 = 1600\, (a + b)\, t^2. \qquad (12)$$

In letting the results of his work go to the press, the writer trusts that they will alleviate a long felt want on the question of strength of materials. If the analysis is not at present quite as complete as desired, the writer hopes to have an opportunity at an early date to finish it more elaborately.

It is a question, at any rate, if the practical engineer and designer, to whom this work is especially dedicated, does not, after all, prefer the graphical and more illustrative results to a rather complex mathematical analysis.

It may be argued that the experimental range of this paper does not include bars of very small dimensions, nor does it include round bars. The writer will reply to such a criticism that round bars are generally very small bars, and small bars are omitted, because nearly all shearing machinery is designed for large dimensions, or such as come inside the scope of this paper.

## ACCIDENTS TO LOCOMOTIVE ENGINEERS AND FIREMEN.

The following is a list of accidents which occurred during the month of March to the class of railroad employés named above. As mentioned in the last number of our Journal, the purpose of this publication is to make known the terrible sacrifice of life and limb among this class of people, with the hope that it will indicate some of the causes of accidents of this kind and help to lessen the awful amount of suffering due directly and indirectly to them. We will be much obliged for any information from any source which will help us to make our list as complete and correct as possible, and which will indicate the causes or the cures for any kind of accidents which occur. The following list includes the accidents which occurred during the month of March of which we have been able to obtain information. Doubtless others have occurred of which we have no knowledge:

### ACCIDENTS IN MARCH.

Wilkesbarre, Pa., March 3.—Engine No. 494 on the Lehigh Valley Railroad exploded her boiler near McKune's Station, 15 miles north of Pittston, this morning, killing William Brown, a pilot, who had been sent to assist the train over the Buffalo division, and fatally injuring Charles Sincebaugh, the en-

gineer; Perry Refenburg, the fireman, and John Schott, a brakeman. The force of the explosion carried the boiler off the frame, and what remained of the engine held the track and ran as far as Falls Station, where it came to a standstill on an up grade.

The engine, it is said, was a "dirt burner," but of what particular type is not stated.

Chester, Pa., March 4.—The "Washington flyer" on the Lehigh & Hudson River Railroad crashed into a freight train near Buttsville, N. J., yesterday afternoon. Fireman Cullen was seriously if not fatally injured.

Richmond, Ind., March 4.—A collision occurred two miles west of this city. A construction train was going west, and came in collision with an east-bound freight. The latter had the right of way, and the order required the work train going west to side-track for the freight, which was overlooked. The trains came together while rounding a curve. When the east-bound train first rounded it, it was moving at a speed of 15 miles an hour, while the work train was going at a much greater speed. Both engineers saw the danger and reversed their engines, but the collision could not be avoided, and the trains came together with a crash. Following is a list of injured: C. M. Jennings, Indianapolis, brakeman, head cut and bruised; Daniel Lyons, fireman, Indianapolis, side hurt, internal injuries; Bernard Leonard, brakeman, head cut, side and shoulder injured; William Lock, brakeman, Cambridge City, leg injured. The engines were smashed and several cars derailed.

Buffalo, N. Y., March 4.—While Engine No. 692 was drawing the New York State Express, when about three miles east of Crittenden, the pin holding in place the side-rod on the right side of the engine broke. It crushed through the cab, paring it off as smoothly as a knife would have done. Fireman Marle was severely injured internally. His arm was also crushed, his back strained and his face considerably bruised.

About half an hour later another accident occurred which was almost identical. This likewise happened a few miles west of Batavia. A west-bound freight train was traveling rapidly when the rod connecting the driving-wheels of the engine broke. There was a general smash as a result. Two of the wheels were separated from the engine and the others were badly damaged. The engine is a complete wreck. No one was injured.

Cincinnati, O., March 5.—Three men were fatally injured in a smash-up in the Little Miami Yards, on Eastern Avenue, this morning. A number of freight cars were standing on the tracks and through a misplaced switch two yard engines crashed into them. The engineer jumped and escaped serious injury. Fireman Joseph Lee received injuries which will result in his death. Brakeman Charles Walker and Patrick Donnelly were also fatally injured.

Hagerstown, Md., March 5.—The boiler of a freight locomotive exploded about nine o'clock in the evening while drawing a heavy train on the Western Maryland Railroad at East Hagerstown Station. The engine had just passed the station when the accident occurred. H. Hawk, fireman, was blown from the cab to the top of a shed about 30 ft. away. The clothes were torn from him and he was blistered from chin to hips. One arm was broken. Mr. Hawk will probably die.

The engineman, George P. Smith, was blown from the locomotive by the force of the steam and one of his legs was broken. He was also badly cut. Brakeman Thomas Lefevre, also of Hagerstown, who was on the locomotive, was thrown from it. His back was severely hurt and he was scalded.

The train was going down-grade at the time, as said, and without engineman, fireman or front brakeman, drifted along to Antietam, two and one-half miles distant, where the up-grade begins and where the train stopped. The rear brakeman, who knew nothing of the accident, hurried forward and discovered the peculiar and serious state of affairs. Trainmaster Shreiner was informed of the occurrence, started with a yard locomotive to investigate, picked up the injured men and cautiously followed the train, catching it at Antietam. None of the men can tell how the accident occurred. The engineman says he had the injector at work and the steam cut off, and that the train was drifting along. It is said the boards in the front of the tender looked as if riddled with shot, so fiercely had the vapor driven pieces of coal into them.

Punxatawney, Pa., March 6.—Arthur Jones, a fireman on a locomotive, was badly burned on Monday night by the bursting of a pipe.

Stevens Point, Wis., March 6.—The right side-rod on engine No. 23, on the Wisconsin Central Railroad, broke and severely injured Engineer J. H. Hollman in the back and hips. The accident occurred two and one-half miles west of Stanley while making a curve, and the train being at a low rate of speed little damage was done, aside from the injury of its engineer. No serious results are anticipated as the result of his injuries. The accident was similar to one which occurred a couple of weeks earlier, in which Engineer McMillan got a severe shaking up.

Stevens Point, Wis., March 7.—A passenger train met a local freight in a head-end collision at Hewitt, on the Wisconsin Central Railroad. Three crews jumped and left their engines, as one locomotive crashed into another. Two were slightly injured in this wreck. A. P. McMillan, engineer of the passenger train, received a bruise in the face, disfiguring his nose; and Fireman Harry Spaulding sprained his ankle in jumping out of the cab window to the ground. The accident was attributed to the absence of a light at a switch which was open.

On the 9th an express engine on this same road "lost a driving-wheel tire," but no one was injured.

Quakertown, Pa., March 9.—Passenger train No. 328 on the north branch of the Reading Railroad ran into a landslide near Bingen last evening. Engineer Alfred Degrant was killed and his fireman badly hurt. The baggage-master was slightly injured. The passengers were badly shaken up, but no passenger was injured. The engine and three cars were wrecked.

Deckertown, N. J., March 9.—The Boston Express, on the Lehigh & Hudson River Railroad, ran into the rear end of a freight train, demolishing the engine of the express, wrecking the caboose of the freight and severely injuring the fireman of the express.

Petersburg, Va., March 11.—A collision occurred on the Atlantic Coast Line at Weldon, N. C., caused by a vestibule express train, north bound, running into the caboose car of a freight train which was standing on the main track. The occupants of the caboose were Conductor Edmund Gee, of Petersburg, and Engineer J. Clayton, of Richmond, both of whom were injured. The locomotive and baggage car of the express were derailed.

Scranton, Pa., March 11.—By the breaking of the parallel rod of the engine of No. 1 passenger train on the Delaware, Lackawanna & Western Railroad, near Moscow, the boiler of the engine was pierced, and the escaping steam forced Engineer Albert Tingley, Fireman Matthew Deveren, and Ashman Edward Giles to jump from the cab. They were so badly injured that all three may die. Tingley was badly scalded about the hands and face. He also suffers severe pain in his back, and it is feared that his spine is seriously injured. Before he jumped he set the air-brakes and brought the train to a stop, thus averting a serious disaster. Giles is terribly scalded about the face, the flesh appearing to have been boiled. Davern's worst injury is his broken leg.

Hartford, Conn., March 13.—Locomotive No. 320, of the Philadelphia, Reading & New England Railroad, exploded at St. Elmo, N. Y., ten miles west of Poughkeepsie Bridge this morning.

George A. Shufeldt, fireman, of this city, and Horace Lambert, brakeman, of Bangor, N. Y., were instantly killed, and Engineer James Flannigan, of this city, was fatally injured.

The engine, which was making its first trip after having been thoroughly repaired in the shops here, was drawing an east-bound extra freight. The crown sheet gave way.

Bolingbroke, Ga., March 14.—The fast express on the Central Railroad was thrown from the track two and one-half miles from Bolingbroke. The engine and all the coaches except the parlor cars are in ruins. No lives were lost. The engineer, Ramsey, is seriously hurt and the fireman is slightly scalded.

Elkton, Md., March 15.—A freight wreck occurred at North-east, on the Philadelphia, Wilmington & Baltimore Railroad. An extra north-bound freight train was side-swiped by another freight engine, derailing the engine and demolishing about a dozen cars. Joseph Howard, of Philadelphia, engineer, was slightly injured.

Hartford, Conn., March 16.—Two locomotives were wrecked and three cars derailed by a collision of freight trains at Simsbury. Engineer Jack Lynch, of Hartford, ran his extra freight into town at such a rate of speed that he could not stop in time and ran head on into train No. 33, which was at a standstill. Lynch and his fireman jumped, and the former's leg was broken and his face and body badly bruised.

Hazleton, Pa., March 16.—While Pennsylvania Railroad engine No. 409 was going down the mountain it became disabled and was run on to a siding. Swenk, the flagman, became confused, and turned the main switch. Lehigh Valley engine No. 525 came around the curve at a rapid rate of speed and dashed into the disabled engine. John Jenkins, a cook on the tool car, was badly injured. The car immediately took fire and was destroyed. Kleckner, the conductor of the Lehigh Valley train, had a leg broken, and Shuman, the engineer of the Pennsylvania train, had an arm broken.

Port Jervis, N. Y., March 16.—The engine of train No. 12 on the Erie Railroad broke down, which caused a halt of 15

minutes at Lackawaxen to await the arrival of another engine. While standing there, No. 12 was run into by train No. 10, the Buffalo express, which was closely following the Chicago train. The train was badly wrecked and fourteen passengers were seriously injured, some of them fatally.

Engineer Canfield and Fireman Boyd, of train No. 10, stuck to their engine until the crash came, and they escaped serious injury. They extricated themselves from the wreck and joined the passengers and train hands in removing the injured to the Lackawaxen station.

Butte, Mont., March 18.—A 55-ton Grant locomotive exploded with terrific force, instantly killing Engineer H. J. Winkerwoerder and Switchman John Kane; Engineer Paul Fetherkyle was fatally and Fireman James Mulligan seriously injured. The locomotive was owned by the Montana Union Railroad Company, and was ascending the hill with 12 empty ore cars for one of the Anaconda Company's mines.

Evanston, Wyo., March 18.—An east-bound Union Pacific express train ran into an open switch near this place, and the result was a bad wreck, in which B. F. Gay, a postal clerk, was killed and Engineer Lethbridge seriously scalded.

Mahanoy City, Pa., March 18.—A Reading locomotive exploded while standing on a siding near the station in the central part of the town. Engineer John Schuyler and Fireman William Wells, who were in the cab at the time, were thrown in the air and so badly battered and scalded that they cannot survive.

The hot coals from the fire-box were scattered in all directions, and, falling on buildings in the vicinity, set fire to and destroyed a number of them. At one time there were fully a dozen houses on fire.

Norristown, Pa., March 20.—Engine No. 834, with a coal train attached, ran off the track just this side of Pottstown, near Sanatoga, on the Philadelphia & Reading Railroad. After running along the ties for 20 yards it plunged down a 20-ft. embankment, carrying the engineer, John McCormick, aged 34 years, with it.

The fireman, Thomas McLaughlin, aged 27 years, jumped and escaped with a cut face and head; the engineer, with a broken arm and a severely shocked system. A broken rail is responsible for the damage.

Greensburg, Pa., March 21.—William McGough, engineer on one of the Derry local freights, was painfully injured in jumping from his engine near Radebaugh. Seeing an empty engine ahead of him, he became alarmed, and, reversing his engine, jumped off. He was thrown violently on the ballast, breaking his right arm, bruising his leg and sustaining a number of cuts about the head and face.

Brooklyn, Ia., March 21.—Engineer Le Clare met with a painful and serious accident Tuesday evening on the Chicago, Rock Island & Pacific Railroad, which will lay him up for several days. He was coming west on a fast freight, and his was the second engine of a double-header. East of here a piece of coal fell from the forward engine to the ground and bounded up just in time to catch the second engine. Le Clare was sitting on his seat in the cab and the coal came crashing through the window-sill and struck him upon the jaw. The wound proved both serious and painful. Le Clare was able to return to his home at Rock Island on the evening passenger train.

Worth, Ill., March 21.—William Johnson, a Wabash engineer, was instantly killed yesterday morning by a gas explosion. His train stopped here for water and coal, and three brakemen tried to remove the cap from the small oil tank on the engine. It was a hard job, and Johnson went to their aid, taking with him a wrench and his lantern. As he removed the cap the escaping gas which had accumulated became ignited and an explosion followed. Johnson was hurled nearly 100 ft., and when picked up was dead. The brakemen escaped with only slight injuries.

Bellevue, O., March 23.—The tender of a work train was derailed about 15 miles south of Bucyrus while backing, and dragged the locomotive with it down an embankment, and eight cars followed. Engineer Van Horne received a painful but not dangerous scalp wound. Fireman R. Sams received severe injuries in his hips and legs, besides internal injuries, the extent of which cannot yet be determined. The brakeman, Charles Jennings, of Columbus, ran back from the tender, jumping from one car to another as fast as they left the track, until he reached the ninth car, which remained on the rails.

Herkimer, N. Y., March 27.—Engineer Charles Barrett, of this place, was seriously injured in the accident on the Adirondack Railroad. He will probably recover.

New Haven, Conn., March 27.—Frank Stevens, a locomotive fireman on the Consolidated Railroad, while standing on the side of his locomotive was caught between the round house and the locomotive cab and badly pinched.

Philadelphia, Pa., March 28.—Several mischievous boys unfastened the brakes on a loaded gondola standing on the side tracks of the Reading Railroad near Park and Lehigh avenues, and in a few seconds it was going down the grade at a high rate of speed in the direction of Huntingdon Street, just below which it collided with a shifting engine in charge of Engineer David Hendricks. One side of the cab was torn from its fastenings, the steam fixtures were broken, and the engineer was forced from the footboard to the side of the track and badly scalded by escaping steam. The engine was stopped before any further damage was done.

Birmingham, Ala., March 30.—Two north-bound freight trains on the Georgia Pacific had a rear end collision at Waco, 111 miles east of here. Engineer William Gray, aged 25, was killed, and Fireman Lewis Mitchell fatally injured. They were in the engine of the second train, which, when it struck, turned over down an embankment, the engine falling on the men.

St. Paul, Minn., March 30.—A frightful accident on the Canadian Pacific Railroad, a few miles east of Harrison, which resulted in the loss of four lives. Among the killed is Stephen White, brother-in-law of Judge Killam, of Winnipeg. Reports are that the engine jumped the track while on a dizzy height, overlooking the Frazer River. The engineer and fireman, seeing no chance to escape by remaining in the cab, jumped for their lives into the deep gorge. The engine at the same moment went down the perpendicular embankment. Nothing was seen of the men after they jumped from the engine. Two others were killed, one being Mr. White. Nothing was learned of how he met his death.

Our report, it will be seen, includes 35 accidents, in which seven engineers and six firemen were killed and 18 engineers and 15 firemen were more or less seriously injured—some of them probably fatally. The causes of the accidents may be classed as follows:

| | |
|---|---|
| Boiler explosions | 5 |
| Bursting of pipe | 1 |
| Broken crank-pin | 1 |
| Broken coupling-rod | 4 |
| Open switch | 1 |
| Derailments | 4 |
| Collisions | 11 |
| Land slide | 1 |
| "Side-swiped" | 1 |
| Jumping from engine | 1 |
| Struck by coal | 1 |
| Lost tire | 1 |
| Caught between locomotive and engine-house | 1 |
| Gas explosion in car | 1 |
| Unknown | 1 |
| Total | 35 |

The Reading Railroad, as usual, leads in boiler explosions, and is credited with two. Four broken coupling-rods seems a large number for one month; and if we add the one broken crank-pin—probably due to the same cause—it should lead to serious inquiry as to whether this danger may not be lessened.

Collisions, as might be expected, are the chief cause of accidents. To prevent these entirely both human nature and the laws which govern inanimate things would have to be completely changed.

Our record has not been kept long enough to be very instructive, but it shows that, if the rate of mortality for March is an average for the year, 156 engineers and firemen are killed, and about 400 are injured annually in this country. Doubtless our record is very much below the real average, as the only means we have of getting reports of accidents is from the newspapers, and these are always imperfect.

We repeat our request, made at the beginning of this article, that persons in positions to hear of accidents to engineers and firemen should send us reports of them.

## COLUMBIAN EXPOSITION NOTES.

**The Bethlehem Iron Company's Exhibit.**—This display will be the heaviest at the Columbian Exposition, weighing 1,000,000 lbs. There are four armor plates, a 17-in. plate for the *Indiana*, a nickel steel barbette weighing 70,000 lbs., an 11½-in. plain steel plate, a 10½-in. case of hardened nickel steel plate and a 6-in cylindrical ventilator for the *Puritan*.

**A United States Army Balloon.**—It is reported from Washington that General Greely has purchased from the French baloon-maker, Lachambre, a military balloon, which is to form a part of the War Department's exhibit at Chicago.

The balloon has a capacity of 13,000 ft. and will cost 9,000 francs. It is to be made of goldbeater's skin, and the contract

price includes basket, ropes, sandbags, drag, and other accessories of military balloons.

A detachment of Signal Corps Sergeants will be sent to the Exposition grounds to join the force already there, that practical illustration may be given of the methods of signaling in the army, including the operation of this military balloon. It is said that this will be a "regulation, globular, captive balloon," attached to the basket of which is a light wire, extending to a huge reel, which allows the wire to unwind as the balloon ascends, and serves to pull the balloon back to camp. The wire has a double use, in holding the balloon and furnishing the occupants of the basket a means of communicating, as by telephone, with the officers at the reel.

**Indiana's Coal Exhibit.**—The Indiana coal operators have arranged to make an elaborate exhibit, the block coal interests to be represented by the Brazil Block Coal Company, and the bituminous mines by the Foley Mine. The latter was agreed upon for the reason that it can furnish a larger block of coal than any of the other bituminous mines, owing to the mine's lesser depth. The block of coal from the Foley Mine will be over 7 ft. in height. The other mines in this vicinity will also make exhibits. The Hocking Valley will have on exhibit a block of coal showing a vein 16 ft. 3 in. in height, and New South Wales will have coal from 10-ft. veins, but the latter, owing to the presence of sulphur, is not so good as either the Hocking Valley or the coal of this district. Governor McKinley has placed Ohio's coal exhibit in charge of the State Mine Inspector, and the operators of this State will urge Governor Matthews to put Mine Inspector McQuade in charge of Indiana's exhibit. It is believed that such a plan would largely enhance the merits of an industry that is second to none in the State's wealth.

## CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.

### Chemistry Applied to Railroads.

### SECOND SERIES.—CHEMICAL METHODS.

### II.—METHOD OF DETERMINING FREE CAUSTIC AND CARBONATED ALKALI IN SOAPS.—*Continued.*

BY C. B. DUDLEY, CHEMIST, AND F. N. PEASE, ASSISTANT CHEMIST, OF THE PENNSYLVANIA RAILROAD.

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(*Continued from page 200, Volume LXVII.*)

NOTES AND PRECAUTIONS.

IT will be observed that the method above given for determining carbonate of soda in soaps is based on the insolubility of this salt in a solution of soap in absolute alcohol, and that the method for getting the free caustic alkali dissolves the soap in presence of an acid which cannot decompose it, which has but slight action on the carbonate present, and which combines with the free caustic alkali as fast as solution takes place, and enables this constituent and the small amount of carbonate dissolved to be measured.

Positive experiments show that with good absolute alcohol, and with soap which has been freed from water, the carbonate determination is very sharp, the salt being almost absolutely insoluble. Many soaps in the market, however, contain from 5.00 per cent. to 35.00 per cent. of water, and if in addition to this water in the sample 95.00 per cent. alcohol only is used, the solubility of the carbonate of soda becomes quite perceptible. The error in these cases may amount to from 0.10 per cent. to 0.30 per cent. Many of the common soaps contain as high as from 5.00 per cent. to 7.00 per cent. of carbonate of soda, and in such samples this error may perhaps fairly be ignored. Whether absolute alcohol or 95.00 per cent. alcohol is used, it is always desirable to dry the soap, and if this is done, the error, even when 95.00 per cent alcohol is used, is not much over 0.10 per cent. It is believed that if the directions are closely followed in every respect, the error can always safely be ignored.

The solubility of soap in absolute alcohol is apparently not quite as great as in 95.00 per cent. alcohol, and therefore after solution is complete, filtration must proceed with moderate rapidity, or the solution may gelatinize and clog the filter. There is less danger of this the hotter the solution is kept.

If the soap under examination contains uncombined fat acid along with carbonate of soda, as is frequently the case in olein soaps, combination may take place between these constituents in the boiling absolute alcohol solution, and consequently the analysis may be in error to this extent. We do not know of any method of overcoming this difficulty.

The drying of soap is a slow operation at best. It is facilitated by having the shavings very thin, and by having the temperature of the air surrounding the soap at first not hotter than 120° Fahrenheit, and gradually, as the drying proceeds, raising the temperature to not above 200° Fahrenheit. Of course the soap must not be melted, as this would endanger the combination of some of the free or carbonated alkali with free fat, if any were present. Experiments indicate that if the amount of water in the dried soap does not exceed 5.00 or 8.00 per cent., the resulting error can be ignored.

The stearic acid solution, as made from commercial materials, is sensitive to changes of temperature. It is, therefore, essential to prevent it from becoming too cold, or its strength will be diminished by something crystallizing out.

Most of the commercial 95-per cent. alcohol does contain, and the absolute alcohol may contain small amounts of free acid of some kind—probably acetic. The amount of this can readily be determined by the use of standard alkali, and in the carbonate determination this acid must of course be allowed for.

Much of the phenolphthalin of the market apparently contains something which combines with alkali without showing change of color. If this is not satisfied with alkali as directed, the reaction will not be quite so delicate.

We make standard sulphuric acid solution by adding to a clean, clear glass 5-gallon bottle, 15 liters of distilled water, and then weigh out and add to it 397.5 grams of concentrated C. P. sulphuric acid. It is better to set the water in the bottle in motion by stirring with a clean glass rod before adding the sulphuric acid. After the acid is in, it is essential to agitate thoroughly by stirring and shaking, but not advisable to draw air through for this purpose, as this causes the liquid to take up carbon dioxide, which interferes with its subsequent usefulness with phenolphthalin. It is not desirable to standardize on the same day, both on account of temperature and also because, if we may trust our experience, it is very difficult by any practicable method of agitation to get so large a bulk of liquid entirely homogeneous without standing. If the first standardizing shows that it is essential to add say 750 c.c. of water, we usually add only 700, since we expect to standardize once more any way, and too much water must of course be avoided. The second addition of water is usually less than 100 c.c. We regard both agitation and standing over night essential after each addition of water.

We make caustic potash solution in the same kind of bottle and in the same amount as the acid solution. The same precautions should be taken in regard to stirring, and allowing to stand over night, as in the case of the acid. It is well known that caustic potash solution, if properly made as above described, contains a small amount of caustic lime in solution. Of course this lime will appear in the comparison with the standard acid. If now the water used in the first addition contains a little carbon dioxide, a little of the lime will be precipitated on standing over night, and weaken the solution a little. It is therefore not advisable to add quite as much of the water shown by calculation the first time, as in case of the acid.

We make the two solutions, as will be observed, in quite large amounts, and take considerable pains to have them right, since other work depends upon them. The bulk above described lasts us four or five months. Both of the solutions are kept on a shelf somewhat higher than the burettes, and both are drawn into the burettes by means of glass tube siphons with glass cocks at the lower ends. In accurate work it is of course essential to draw out and throw away the liquid which has been standing exposed between the cock and lower end of the siphon tube before filling the burette. The air which goes in to replace the liquid in the large glass bottles should bubble through caustic potash solution in order to keep out carbon dioxide. We use potash bulbs for this purpose.

The fact that phenolphthalin is sensitive to carbon dioxide in water solution, and to carbonates and bicarbonates, may lead to serious error unless sufficient care is taken to add enough acid to decompose all carbonates and bicarbonates and then expel the gas by boiling before subsequent titration with caustic potash. An illustration will make the matter clear. Let

us suppose that in obtaining the relation between carbonate of soda and sulphuric acid in standardizing the acid, the carbon dioxide is not quite all removed by boiling, when we attempt to measure the excess of the acid by means of the caustic potash solution. We add this solution drop by drop, and ultimately reach a point when all the free sulphuric acid is satisfied with the caustic potash; but since phenolphthalin in presence of carbonic acid or carbon dioxide in water solution does not change color until part, at least, of this carbonic acid is also satisfied with caustic potash, we do not get our end reaction when the sulphuric acid is all satisfied, as should be the case, but rather after some further addition of caustic potash. The error is obvious; and if we may trust our experience, there is always uncertainty if carbon dioxide or carbonates are present when using phenolphthalin as indicator. Even carbon dioxide in the standard sulphuric acid solution or carbonates in the caustic potash solution will cause difficulty. Methyl orange, and possibly other indicators, do not give so much trouble from this cause; but all that we have ever tried are so much less sensitive and sharp at the end reaction than phenolphthalin, provided the conditions are right, that we prefer to take the extra trouble. Furthermore, positive experiments show that if the solution is rendered clearly acid with standard acid and boiled for 10 minutes or even less, the carbonic dioxide will all be expelled; so that we think if the directions are closely followed the results will be fairly accurate. It is obvious that if the distilled water used in making the standard acid contains carbon dioxide, there will always be some present, with a consequent liability to uncertainty in the final results. Presence or absence of carbon dioxide in the standard acid can be proved by titrating some of the acid cold with standard caustic potash, using phenolphthalin for indicator, and then titrating another similar portion after it has been boiled. If carbon dioxide is absent, the two tests should show the same figure. If it is present in injurious amount it will be essential to always boil to expel carbon dioxide in all tests where this acid is used before attempting to titrate in presence of phenolphthalin.

It is obvious if a soap contains more free alkali than is sufficient to combine with all the stearic acid in 100 c.c. of the stearic acid solution taken, it will be necessary to either use more of the stearic acid solution or diminish the amount of soap to start with.

If a soap has silicate of soda in it, this apparently breaks up in the stearic acid solution, part of it counting as caustic soda and part of it remaining behind on the filter, possibly as insoluble acid silicate of soda. Borate of soda also breaks up in the stearic acid solution, and part, at least, of the base counts as free caustic alkali. We have never carefully investigated the behavior of these substances in the absolute alcohol solution, as, if either of them are present in any perceptible amount, the soaps would not fill our specifications.

It will be observed that in the calculations the results are reported in terms of soda salts. This is because our specifications for soap are so drawn. Of course the results could be reported in potash salts equally well.

We usually calibrate burettes by filling them with distilled water at about 70° Fahrenheit, and then draw out into a flask, and weigh each 5 c.c. to the bottom, and then fill again and start 1 c.c. lower down, and proceed as before. Two or three times through in this way will check any discreppancies that will seriously affect the result. Of course each 5 c.c. should increase the weight 5 grams, and if the burettes are fairly well graduated the differences should not be over the weight of one drop, approximately 50 milligrams. Obviously by using a good balance and going through the burette times enough, the calibration can be made as fine as the graduation. We do not, however, regard this as necessary. It is hardly necessary to add that the burettes to be used with the standard acid and alkali must be alike, or, indeed, interchangeable.

It is well known that change of temperature affects all volumetric work, and it is equally well known that there is no error from this cause if the solutions are used at the same temperature at which they are standardized. We usually keep our standard solutions on a shelf near the ceiling of the room, where the temperature is about 80° Fahrenheit, and standardize them finally after they have been at this temperature over night. With most of the determinations for which we use these solutions, a change of temperature of 10° Fahrenheit does not introduce a greater error than would be produced by one drop of the solution in excess. As we cannot work closer than one drop, except by using weaker solutions, the error of temperature is usually ignored. Of course in very fine work care should be taken to use the solutions at the temperature at which they are accurate.

It is of course well known that other materials than carbonate of soda have been recommended as the starting-point in making acid standard. It is entirely possible that some of these are better than carbonate of soda, but it is believed that if the directions are closely followed, the results will be fairly accurate.

The use of stearic acid to combine with and measure the free caustic alkali in soaps is believed to possess advantages which do not inhere in other acids. First, the solution keeps unchanged almost indefinitely, which is not the case apparently with oleic, and possibly not with palmitic, both of which, as well as stearic, may be constituents of soap, and both of which might possibly be used in place of stearic. Second, the soap apparently not being decomposed, no question can arise as to whether recombination takes place in the same way during the subsequent titration. Third, stearic acid is so weak that its action on carbonate of soda, even in boiling alcoholic solution, is slow and if the soap is cut in quite thin layers, and titration takes place as soon as solution is complete, the carbonate dissolved does not amount to more than 0.25 per cent. Fourth, many of the strong mineral acids act on the organic constituents of the soap, and hence their use is admissible. Also all the stronger acids, even organic ones, dissolve carbonate of soda quite readily, as well as decompose the soap.

It is obvious that there may be a number of conditions in soaps obtained in the market. First, there may be an excess of unsaponified fat, arising from failure of the soap-maker to use enough caustic alkali. In this case, if there is also no carbonate present, the method as described above shows nothing; that is, the titration of the stearic acid at the end of the operation gives the same figure as the titration of the stearic acid alone. We have had cases of this kind happen in our experience. It is obvious that the addition of a known amount of alkali in alcohol to a case like the above, with subsequent boiling and determination of the excess of alkali, would give the amount of unsaponified fat present. We have not experimented with this, however. If carbonates are present, some of the stearic acid would be used up, since this acid in boiling alcoholic solution acts slowly on carbonates, and it would require a carbonate determination as described before it could be stated that the soap is free from caustic. This statement of course involves the idea that unsaponified fat in a soap is not decomposed by carbonate of soda in boiling absolute alcohol solution, as described in the carbonate determination. We have not proven this, however, our experiments only showing that carbonate of soda is insoluble in a boiling solution of soap in absolute alcohol. It would almost seem safe to conclude from this, however, that since carbonate of soda is insoluble, it could not act on free fat. Second, there may be an excess of free fat acid in the soap, owing to the same reason as before —viz., failure to add enough alkali. This is liable to be the case with soaps made from rosin, and in the so-called olein soaps. In this case the method as described, if no carbonates are present, enables the amount of this free fat acid to be determined. The titration of the solution actually gives a higher figure than the stearic acid alone, the excess of course being due to the free fat acid in the soap. We have had many cases of this kind. If carbonates are present in amount just sufficient to satisfy the free fat acid in the soap, and if the boiling is continued long enough so that these carbonates are just decomposed, neither the method for determining carbonate nor that for determining caustic will reveal this fact. For all other proportions of carbonates along with free fat acid in a soap, the methods given enable close approximations to the facts to be obtained. Third, there may be free caustic alkali along with free unsaponified fat. In this case, whether carbonates are present or not, the methods as given are applicable, and give the actual state of affairs in the soap. Fourth, there may be free caustic alkali along with free fat acid. In this case, if carbonates are not present, and if the amount of caustic is just sufficient to satisfy the free fat acid, neither of the methods reveal the facts, since the free fat acid and free alkali would combine on solution of the soap. For all other proportions of free caustic alkali an approximation to the state of affairs may be obtained by the methods as given. If carbonates are present along with free fat acid and free caustic alkali, and if the amount of both of these is just sufficient to satisfy the free fat acid, neither of the methods reveal the facts. For all other proportions the same remarks apply as above. Fifth, there may be free caustic alkali along with normal soap. In this case, whether carbonates are present or not, the methods are applicable, and reveal the state of affairs. It is obvious from the above discussion that soaps containing free fat acid along with just enough caustic and carbonated alkali to combine with the free fat acid cannot be successfully examined by the methods given. It is believed that in all other cases the methods given enable a satisfactory opinion to be expressed in regard to the soap.

(TO BE CONTINUED.)

## PROCEEDINGS OF SOCIETIES.

**Civil Engineers' Society of St. Paul.**—At the monthly meeting, held on April 3, Mr. Eastabrook read a paper on the Isthmus Canals and their Relations to a Deep Water-way between the Great Lakes and the Atlantic Seaboard at New York. He gave a history and description which was fully illustrated by maps of the Suez, Panama, Nicaragua and Erie canals, touching lightly upon exhausted tables of statistics, and closing with the expression of some broad views on the subject of canals.

**The Montana Society of Civil Engineers.**—At the April meeting Mr. A. E. Cummings read a paper on the West Gallatin Irrigation Canal, in the course of which he said that his experience led him to believe that about $1\frac{1}{2}$ miner's inches of water per acre were required for proper service for irrigation in Montana.

In the discussion President Haven said that he had recently measured the amount of evaporation for a reservoir having a surface of 46 acres, and an average depth of 12 ft. No water had been drawn from the reservoir for one year and none supplied except by rainfall; there was little seepage, and the total evaporation for the year amounted to 10 in.

**Liverpool Engineering Society.**—At the meeting of March 8 Professor H. S. Hele-Shaw read a paper on the Graphical Method of Solving Engineering Problems. It was pointed out that a very large proportion of graphical statements take the character of either Cartesian diagrams or polar diagrams. Various text and pocket-books were referred to in which were seen the increase of plotted curves for representing the proportion of valves, the proportion of belts, ropes, screw propellers, boilers, the teeth of wheels, girders, pipes, bolts, coal consumption, etc. Another use of plotted statements are plotted tables for numerical calculation, such as the abacus of Lalanne.

Inquiry was made into the graphical methods of operation which correspond to arithmetical or algebraical operations. Just as we have books in algebra, such as addition, multiplication, progression, etc., we may naturally look for graphical rules and processes which shall enable us to perform similar operations.

Coming next to the actual mode of graphical operation, the author said that we may place first and foremost, in utility, simplicity and frequency of employment, the method of "interpolation," which merely consists in finding from any graphical statement in the form of a continuous curve an intermediate value by drawing a line at the point required, as, for instance, to find the pressure in an indicator diagram at any given stroke.

The actual graphical operations other than the mere construction of linear and polar diagrams were then considered at some length. Examples of cranes, roof-truss and other diagrams were taken, and the method which is known as "Culmann" was given, after which the author concluded by saying that the few examples which were given in the foregoing paper were sufficient to indicate the wide field which is opened out by graphical processes, the possibilities of which seemed almost infinite. And now that modern or projective geometry, which deals not merely with plane surfaces, but with lines in space, had been directly applied—first by Culmann, and since by other writers—to the subject of graphical statics, there appears to be no limit to the number or variety of engineering problems which may be thus dealt with. What is wanted at the present time is a clearer understanding of the foundations of the subject, so as to collect and bring into a more definite system the rapidly growing number of problems and publications of all kinds which deal with graphical statements and operations.

**American Society of Civil Engineers.**—A paper was read at the meeting of April 5 by Walter McCulloh on a Water-tight Masonry Dam. The dam described was the Sodom Dam on the Croton Aqueduct. The greatest height of the dam above the rock is 98 ft., and the thickness at the bottom is 53 ft.

The emergencies which have to be guarded against in the construction of the dam lay in the fact that the stream rises very suddenly, and the discharge in the spring freshet sometimes reaches 250,000 cub. ft. per minute. To control this during construction, a timber crib dam was thrown across the river about 80 ft. above the site of the work, and a canal cut 26 ft. wide and 15 ft. deep on the west side and around the work to a point 500 ft. below. The gate-house and eastern half of the dam were then built to about 35 ft. above the discharge pipes, and in the dry season of 1889 the water was turned through the pipes and the other half of the dam started.

In preparing the foundation, all loose rock was removed, and afterward all loose seams or shakes. The foundation was swept with wire stable brooms and washed clean. All pockets or holes were then filled with rich Portland cement concrete. A tighter bond, it was found, could be made with rubble consisting of small stones than with concrete beds. Water entered through several seams in the rock, and would wash the mortar out of the concrete, but it could be led around the rubble beds, until finally a small well 2 ft. in diameter and 1 ft. deep was formed at the point where the water boiled up. After the mortar had set, the well was bailed out and filled quickly with dry mortar; on top of this a bed of stiff wet mortar was laid, and capped by a large rubble stone. After the first 6 ft. of the rubble foundation had been placed there was no further trouble.

The dam for about 40 ft. of its height is of rubble masonry laid in Portland cement mortar mixed 2 to 1. Above this there was facing stone 30 in. deep, laid in 2 to 1 Portland cement mortar, backed with rubble in mostly 2 to 1 mortar. The rubble stones varied from a cubic foot to a cubic yard in bulk, and were laid in full beds of mortar. There were no through horizontal joints. Joints were filled with mortar, into which as many stone spalls were forced as was possible. All stone was washed before using. Sand and cement were mixed dry, and then wet only when required. All cement passed through a sieve of 10,000 meshes, and was carefully tested. All loamy sand was rejected. The face stone was a light bluish gray limestone, cut rectangular, with rock face. Stretchers were 3 ft. to 6 ft. long × 30 in. wide, and headers 4 ft. long. The thickness of courses diminished from the bottom up. The beds were at right angles to the face, and the stone had to be held in place with wooden blocks and wedges, to prevent slipping until the mortar had set, after which the blocking was removed and spaces left were filled with rubble.

Stone setting was done by the use of the cable, the traveler and derricks. The cable consisted of a $2\frac{1}{4}$-in. steel-wire cable, stretched over and parallel to the dam, and over towers 667 ft. apart, and anchored in the bedrock. On this a trolley ran which was worked by a double-drum reversible engine. A load of 10 tons would sag the cable 25 ft. with a clearance of 5 ft. above the coping. Most of the excavation was removed, and all material delivered on the wall in this manner. The cost of the cable erected was $3,750. The first cable after 15 months' use parted without warning, under a load of 6 tons, the break being probably due to unequal wear at the point where stone and cement were hoisted. The towers were then raised 10 ft., so as to lessen the tension, and a new cable supplied which lasted until the completion of the work. When the wall had reached a point 31 ft. below the top, the standing derricks were replaced by a traveling derrick mounted on a 30-ft. trestle and running on a track of 36-ft. gauge; a boom 55 ft. long was used with this derrick.

The dam is water-tight. With 68 ft. of water behind it no leaks whatever have been found, either through or under the wall or around the ends. Sweating at the joints appears at points, but not so much as to cause a trickle; but it cannot be seen on a dry day. This very desirable result is due to the excellent materials used, the care in preparing the foundation, thorough cleaning of all stone, care in mixing mortar, breaking of joints horizontally and vertically and close attention by the engineers to every detail. In addition to this, the desire on the part of the contractors to do good work and the existence of a proper relationship between them and the engineers were factors.

## PERSONALS.

Mr. J. C. Halladay succeeds Mr. E. J. Hill as Western representative of the Pickering Steel Company, with office at 719 Phœnix Building, Chicago, Ill.

Mr. James G. Dagron, member American Society of Civil Engineers, has resigned his position as Engineer of Bridges of the Baltimore & Ohio Railroad.

Mr. Theodore Cooper, of the Class of 1858, delivered a lecture on "Specifications" before the students of the Rensselaer Polytechnic Institute, at Troy, on March 29.

Mr. Edward J. Hill, formerly Western representative of the Pickering Steel Company, Limited, has been appointed General Sales Agent, with headquarters at Room 14, No. 80 Broadway, New York City.

W. H. Fry has been appointed General Superintendent of the Car Department of the New York, New Haven & Hartford Railroad. He is to have full charge of all matters per-

taining to the cars and car shops of the Company wherever they may be.

Mr. J. R. Kendrik, General Manager of the Old Colony Railroad, has been appointed Third Vice-President of the New York, New Haven & Hartford Railroad.

Mr. Dudley D. Mayo has been appointed Acting Manager of the Denver & Rio Grande Express, in the place of Mr. George W. Kramer resigned.

Mr. A. E. Manchester, formerly Division Master Mechanic, has been appointed Assistant Superintendent of Motive Power of Chicago, Milwaukee & St. Paul Railroad, with office at Milwaukee, Wis.

Mr. Blaine Gavett has been appointed District Passenger Agent for the Chicago & West Michigan Railroad, the Detroit, Lansing & Northern Railroad and leased lines, with office at 120 Griswold Street, Detroit, Mich.

L. W. Bradley, for a number of years Purchasing Agent, of the Brush Electric Company, resigned recently. H. J. Wendorff, who has been for a long time at the head of the store rooms of the Brush Company, was appointed in his place.

Mr. Edward B. Wall has been detailed for duty as assistant to the First Vice-President of the Pennsylvania lines west of Pittsburg, with office at Chicago. He will have charge of the general interests of the lines (excepting traffic) at that point.

Alfred P. Boller, of the Class of 1861, recently delivered a lecture before the students of the Rensselaer Polytechnic Institute on the Substructure and Approaches of the New Central Bridge over the Harlem River at One Hundred and Fifty-fifth Street, New York.

Jacob S. Rogers, the millionaire owner and President of the Rogers Locomotive Works, has retired from active management of the business. The business will be carried on under the name of the Rogers Locomotive Company, with a capital stock of $3,000,000. Robert S. Hughes, formerly Secretary, will be President of the new company.

Mr. Frederick A. Scheffler, Superintendent of the Brush Electric Company, has tendered his resignation, same to take effect April 1. Mr. Scheffler has for several years past been actively identified with the manufacture of electrical apparatus, and for a number of years previous was engaged in the production of steam-engines and boilers. His address after April 1 will be "Passaic, N. J., care E. K. Rose."

Mr. J. Van Smith, Superintendent of the Philadelphia Division of the Baltimore & Ohio Railroad, has, in addition to his above-named position, been appointed General Agent of the Company for Philadelphia, the appointment dating February 1,1893. He will be the authorized representative of the Executive Department of the Company, and will report directly to the respective heads thereof. For the present his office is at the Baltimore & Ohio Railroad Station, Twenty-fourth and Chestnut streets, Philadelphia, Pa.

## OBITUARIES.

Mr. John Taylor Johnson, first President of the Central Railroad of New Jersey, died in New York City on March 24, in his 73d year, of paralysis. Mr. Johnson's reputation outside of railroad circles was very wide as a collector of fine paintings and as the founder of the Metropolitan Museum of Art in Central Park, of which he was President up to 1889. He was a lawyer by profession, but practised only a few years, having been elected when 28 years old to the presidency of the Elizabethtown & Summerville Railroad. He was President of this railroad and of the New Jersey Central, of which it formed a part, from 1848 until 1877, when he lost most of his fortune through the disasters that at that period affected all of the anthracite coal-carrying roads. He resigned in 1877, and was not associated with the road after that.

Mr. D. H. Neale, who has, for a number of years, been identified with the editorial staff of the *Railroad Gazette*, died in Brooklyn on Wednesday evening, April 5, of cerebral meningitis. He was born in England, September 5, 1849, and practised there as Mechanical Engineer for some years. At one time he was Chief Draftsman of the London & Northwestern Railroad, but later went to Cape Colony as Assistant Locomotive Superintendent of the colonial railroads. He came to the United States in 1883 to represent the *Engineer* at the Chicago Exposition of Railway Appliances, and in November of the same year joined the editorial staff of the *Railroad Gazette*, on which he remained until November, 1888, when he resigned to go to Sydney, New South Wales, as Mechanical Engineer. He returned to the United States in November, 1892, and re-joined the editorial staff of the *Railroad Gazette*. Since that time his principal work has been that of editing a new edition of the "Car-Builder's Dictionary." Mr. Neale possessed a remarkable combination of faculties, and one which especially fitted him for editorial work. He had a keen mechanical insight and a good power of analysis, and, added to this, his facility in the use of language was quite remarkable, for everything which he wrote was characterized by being couched in the purest and most elegant English. His loss is one that will be very seriously felt in the world of technical literature.

Charles R. Peddle, one of the best known railroad officers in the West, general purchasing agent of the Vandalia line, died Wednesday, at Terre Haute, Ind. He had been connected with the Vandalia continuously since it was built by Chauncey Rose in 1851 as the Terre Haute and Indianapolis Road, and he was Superintendent and Master Mechanic in years past. He purchased the first four engines used on the road of Hinckley in Boston in 1851, and superintended their removal to Terre Haute, a difficult undertaking in those days. Mr. Peddle's daughter, Miss Carrie Peddle of this city, is the artist selected by St. Gaudens to design the model for the Isabella coin for the World's Fair.

## THE NEW YORK CENTRAL RAILROAD EXHIBIT AT CHICAGO.

There has just been completed at the West Albany shops of the New York Central Railroad two trains which will form part of the exhibit of this Company at the Columbian Exhibition. One of these consists of the old locomotive *De Witt Clinton*, which has been rebuilt from old drawings still extant, and from the personal recollections of Mr. Buchanan and others who remember the original machine. The old machine has been reproduced as exactly as possible in every particular. It is not a model, but a complete locomotive which has been run under steam. In addition to the locomotive three old cars have also been rebuilt like those which are represented in the silhouette, which has been extensively circulated, and is said to represent the first railroad train in America. This is, of course, an error, but does not detract materially from the interest in the illustration, which is a faithful representation of one of the trains on the Mohawk & Hudson Railroad in its very early days. The locomotive referred to and the cars are a faithful reproduction of the train represented by this old illustration.

In contrast with this is the new engine, No. 999, which Mr. Buchanan has built to represent the practice of to-day. It is very similar to the engine which has been the subject of the illustrations in the series of articles on American and European Locomotives, which are now being published in our pages. This exhibition engine has 7 ft. 2 in. driving-wheels and 19 × 24 in. cylinders. It is one of the finest pieces of work ever turned out in this and, it is safe to say, in any other country. The engine is plainly finished, with little or no useless ornament. The only decorative features are some finished or polished work, which would not ordinarily be put on an engine designed alone for actual service, and some very plain striping, which is done in silver. What attracts attention is the splendid workmanship of every part. The tank work on the tender has never been equalled in this country, and probably not surpassed in European shops, where, it must be admitted, they generally beat us in this especial department. Every part of the engine is finished to correspond with the other parts. The engine and tender are painted plain black, and, as already remarked, with silver striping. All the copper pipes and brass work is silvered so as to correspond with the painting. There are no especial features about the construction of the engine to note, excepting that it is a magnificent piece of work.

The new engine and the rebuilt *De Witt Clinton* and the three cars were all brought to New York, and were exhibited for several days in the Grand Central Depot, where they attracted a great deal of attention. The contrast between the train of 1832 and the new engine and cars of to-day was very striking.

A train of new cars has also been built to accompany the new engine to Chicago, but these were not sent to New York. Some of these are 70 ft. and others 72 ft. 6 in. long over the bodies, the total length being from 80 to 81 ft. over all. The car shop in West Albany is 75 ft. wide. This it was supposed would be ample for all the requirements of any cars that

would ever be built. In the construction of these new cars it was necessary to let them project some distance outside of the doors of the shop. All the cars will be vestibuled.

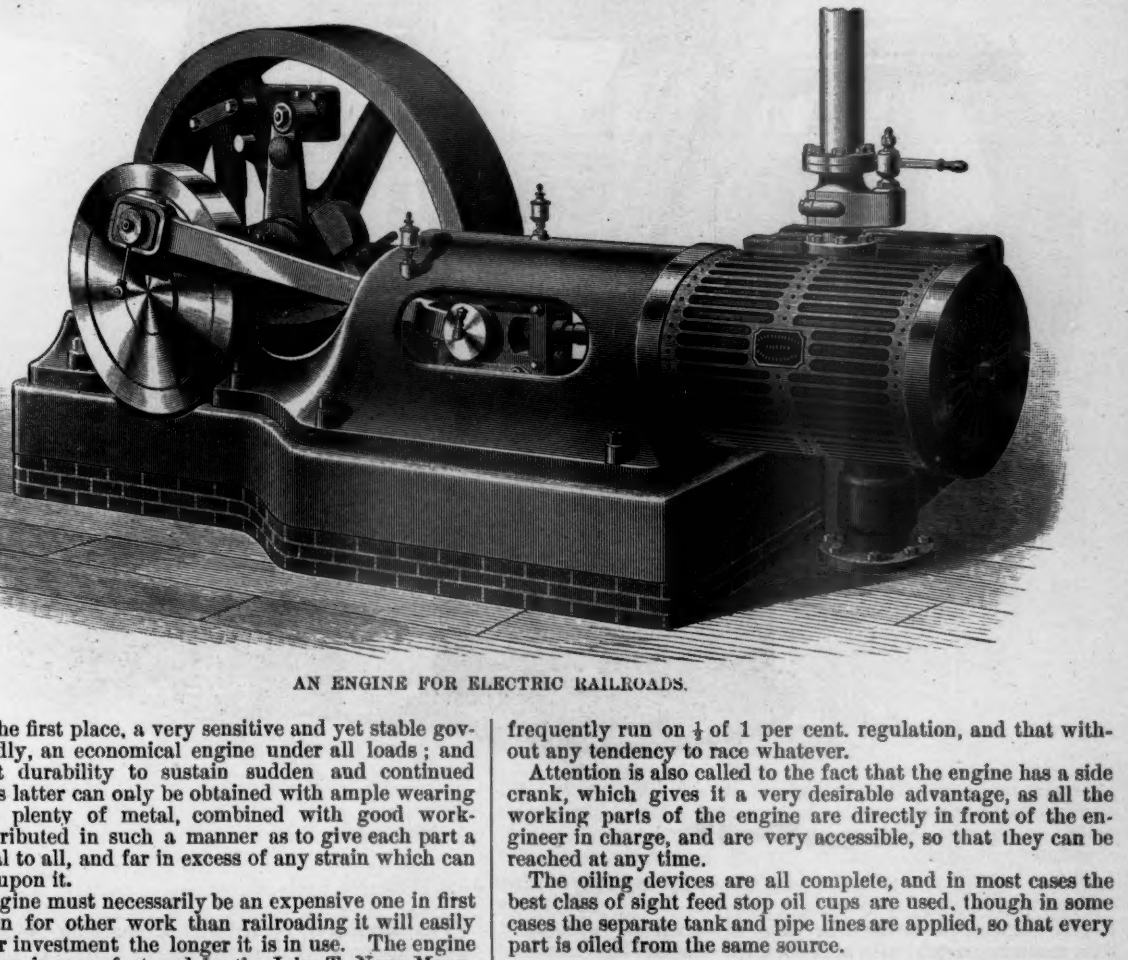
The whole of this work was done under the supervision of Mr. William Buchanan, Superintendent of Motive Power, and reflects great credit on his skill and sound judgment in every particular.

# Manufactures.

## AN ELECTRIC RAILROAD ENGINE.

We present an illustration of one of a particular class of stationary steam-engines which has been developed in the past few years—that is, since the adoption of electricity on street railroads. This service is such an extremely irregular and severe one that it requires an engine especially adapted to it. Probably in no other line of work is it possible to change the load so rapidly and so extremely, running in an instant from no load to full rating, and oftentimes much beyond it. This requires, in the first place, a very sensitive and yet stable governor; secondly, an economical engine under all loads; and thirdly, great durability to sustain sudden and continued shocks. This latter can only be obtained with ample wearing surfaces and plenty of metal, combined with good workmanship, distributed in such a manner as to give each part a strength equal to all, and far in excess of any strain which can possibly fall upon it.

Such an engine must necessarily be an expensive one in first cost, but even for other work than railroading it will easily prove a better investment the longer it is in use. The engine illustrated here is manufactured by the John T. Noye Manufacturing Company, of Buffalo, N. Y., and is known as the "B" style pattern. It is made in sizes ranging from 125 H.P. to 600 H.P., both in single cylinder and tandem compound. The bed, as will be seen, is extremely heavy and massive, containing both top and bottom cross-head slides. These slides are bored, and are very ample in their proportions. The main bearing is provided with quarter boxes, so that it can be taken up at all points. The cylinder on the single-cylinder engines is overhung, and in the tandem compounds there is usually a support placed under the high pressure cylinder. The strength of the bed and of the top slide renders it so stiff that even if there were a tendency to spring in the cylinder it would be impossible. The valve is of the ordinary grid-iron pattern, having four ports; but, unlike the majority of valves, this takes steam from both the inside and the outside, being balanced against everything except a slight exhaust pressure. The steam chest proper is contained within the exhaust chest, and forms a double surface for the valve. While the chest which is shown in the cut is ordinarily used as a steam chest, it is the receptacle of the exhaust. A very desirable feature of this construction is the fact that the engine can be turned over and operated with the exhaust chest cover off, so that if at any time there is a leak in the valve it can be discovered and easily taken up. It also prevents any excessive pressure upon the valve stem stuffing-box and upon the exhaust chest cover joint, which points are frequently a nuisance from leakage produced by an excessive steam pressure. The piston-rods, connecting-rods and main shaft are all of the best forged steel and of very ample proportions. The connecting-rod is provided with a loop at the crank-pin end, in which the brass boxes are set, so it is really impossible for the connecting-rod to let go entirely, even should the wedges or bolts become loose. The governor is placed within the band wheel, and is the form known as shaft governor. It is large, with ample power to control the whole of the valve motion, so that when desired in compounds, both the high and low-pressure valves can be handled with the same governor. The simplicity of the governor is apparent at a glance, and contains as few wearing points as possible. The points of adjustment and its strength give it the ability to handle the engine under any load and under the most varying loads. It is said that these engines frequently run on ½ of 1 per cent. regulation, and that without any tendency to race whatever.



AN ENGINE FOR ELECTRIC RAILROADS.

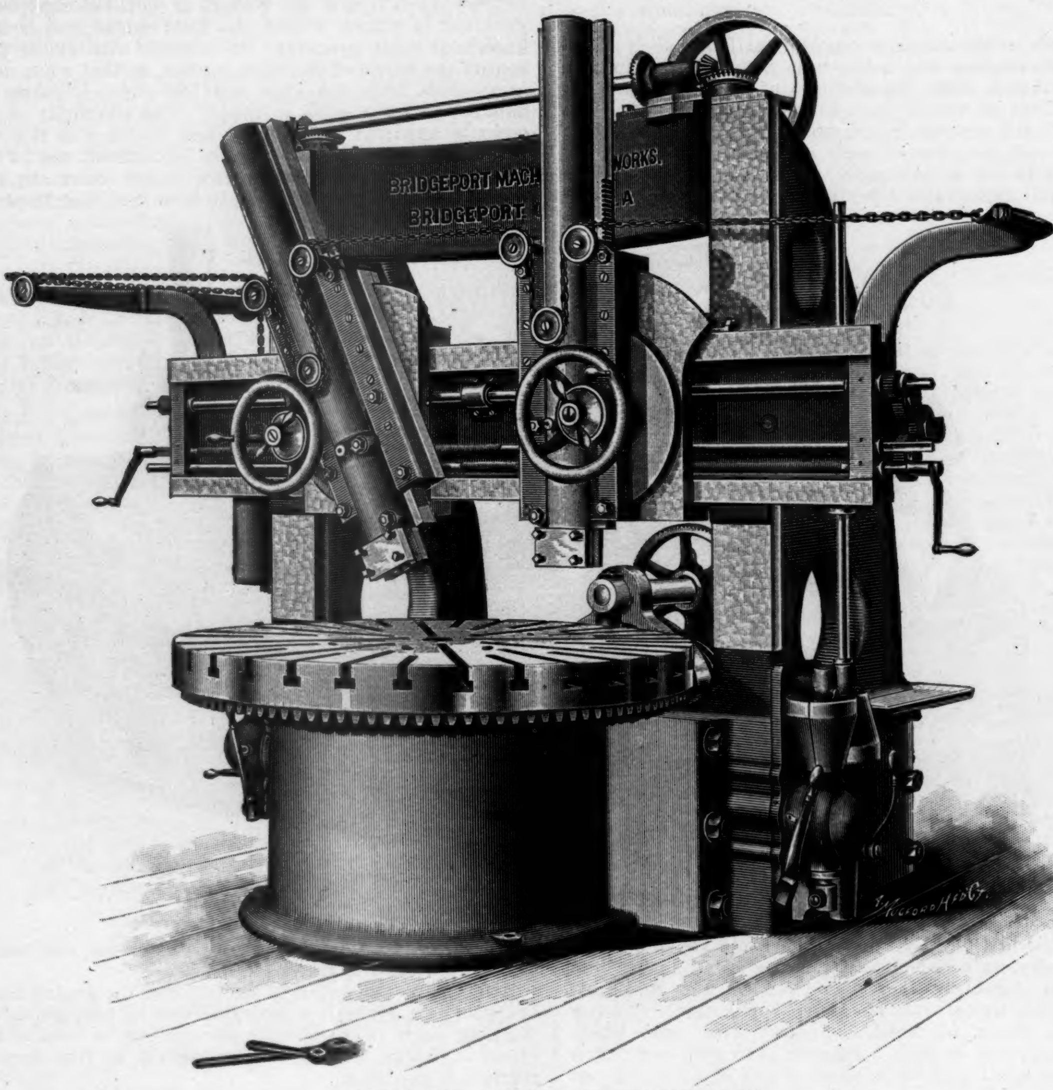
Attention is also called to the fact that the engine has a side crank, which gives it a very desirable advantage, as all the working parts of the engine are directly in front of the engineer in charge, and are very accessible, so that they can be reached at any time.

The oiling devices are all complete, and in most cases the best class of sight feed stop oil cups are used, though in some cases the separate tank and pipe lines are applied, so that every part is oiled from the same source.

## IMPROVED BOLT HEADING MACHINE.

We illustrate on page 257 a new improved bolt heading, upsetting and forging machine built by the Acme Machinery Company, of Cleveland, O. The bed is made in the box form, with three deep trusses running through its entire length to give it great strength. The crank-shaft, which is made of the best forged iron, is carried in three bearings; the face of the bearings being inclined toward the front of the machine, brings the thrust of the forging tools and die closing mechanism against solid metal, and relieves the main caps and cap bolts from all strain. None of the parts subject to wear slide directly upon the bed of the machine, but upon steel and phosphor bronze strips or ways which may readily be removed to be trued up or replaced, thus saving the trouble and expense of

dismantling the entire machine and taking it to the machine shop should repairs be made necessary by such wear as does take place. The machine is also provided with a cushion clutch stop motion, so that when making special forgings, one or more blows can be given as may be required to finish the work. The dies and punches are of novel construction, and will turn out perfect square and hexagon head bolts in three blows or revolutions of the machine. Rivets, track bolts, and many other forgings are made right off the rod, and cut to length by a shear provided in the rear of the dies. An outside shear is provided for, which can be used for cutting off work from the bar after forging. A patent relief wedge serves to prevent the breaking of the bed through the feed gap, should the operator by accident or carelessness allow cold work to get caught between the dies. This illustration is from their 2-in. machine, weight of which complete is about 30,000 lbs.



NEW 62-INCH BORING AND TURNING MILL.

## NEW 62-IN. BORING AND TURNING MILL.

THE machine illustrated is manufactured by the Bridgeport Machine Tool Works, E. P. Bullard, proprietor, Bridgeport, Conn., and is the result of eight years' experience in the manufacture of tools of this class. It embodies all the essential features of their smaller mills, and contains many new ideas which have been suggested by past experience. This company have recently enlarged their works and added many special tools and fixtures for making and handling machines of this character.

The capacity of the mill is 62 in. in diameter and 42 in. in height. The table is 58 in. in diameter, is powerfully geared and has 16 changes of speed. The teeth on table, as well as on pinion, are accurately planed. The heads are constructed so that either one may be brought to the center, and can be set at any angle—they carry the tool bars, which have a movement of 30 in. Each head has an entirely independent feed in any direction. The feeds are all positive, and range from $\frac{3}{64}$ to $\frac{3}{4}$ in. horizontally, and from $\frac{1}{64}$ to $\frac{5}{8}$ in. in angular and vertical directions. The cross-rail is raised and lowered by power. The machine is self-contained, thus avoiding the necessity for building an expensive foundation, and weighs 20,500 lbs.

## General Notes.

**The Baltimore & Ohio Railroad** is asking bids on a large number of freight cars.

**The Eppinger & Russell Creosoting Works** removed their office on April 1 to the Morris Building, corner of Broad and Beaver streets, New York.

**The New York Central & Hudson River Railroad Company** have placed an order for 1,200 freight cars, which are to be equipped with the New York Air-Brake Company's improved automatic freight-car brakes.

**The Wheeler Condenser and Engineering Works** of Carteret, N. J., recently cast a very large steam cylinder for the new steamer building for the Old Colony Steamboat Company. The gross weight of the cylinder is about 38,000 lbs.; it is 95 in. diameter by 11 ft. piston stroke, and some $2\frac{1}{4}$ in. thick, bored, and is a very handsome piece of work.

**Preventive of Timber Rot.**—According to *La Gênie Civil*, timber may be rendered impervious to damp and to steam by use of the following composition: Sulphur, 50 parts; resin, $37\frac{1}{2}$; and fish oil, $7\frac{1}{2}$, are melted together in an iron pot; when in complete fusion a little oxide of iron is added. The

mixture is applied hot, the first coat being allowed to become dry before the second coat is added.

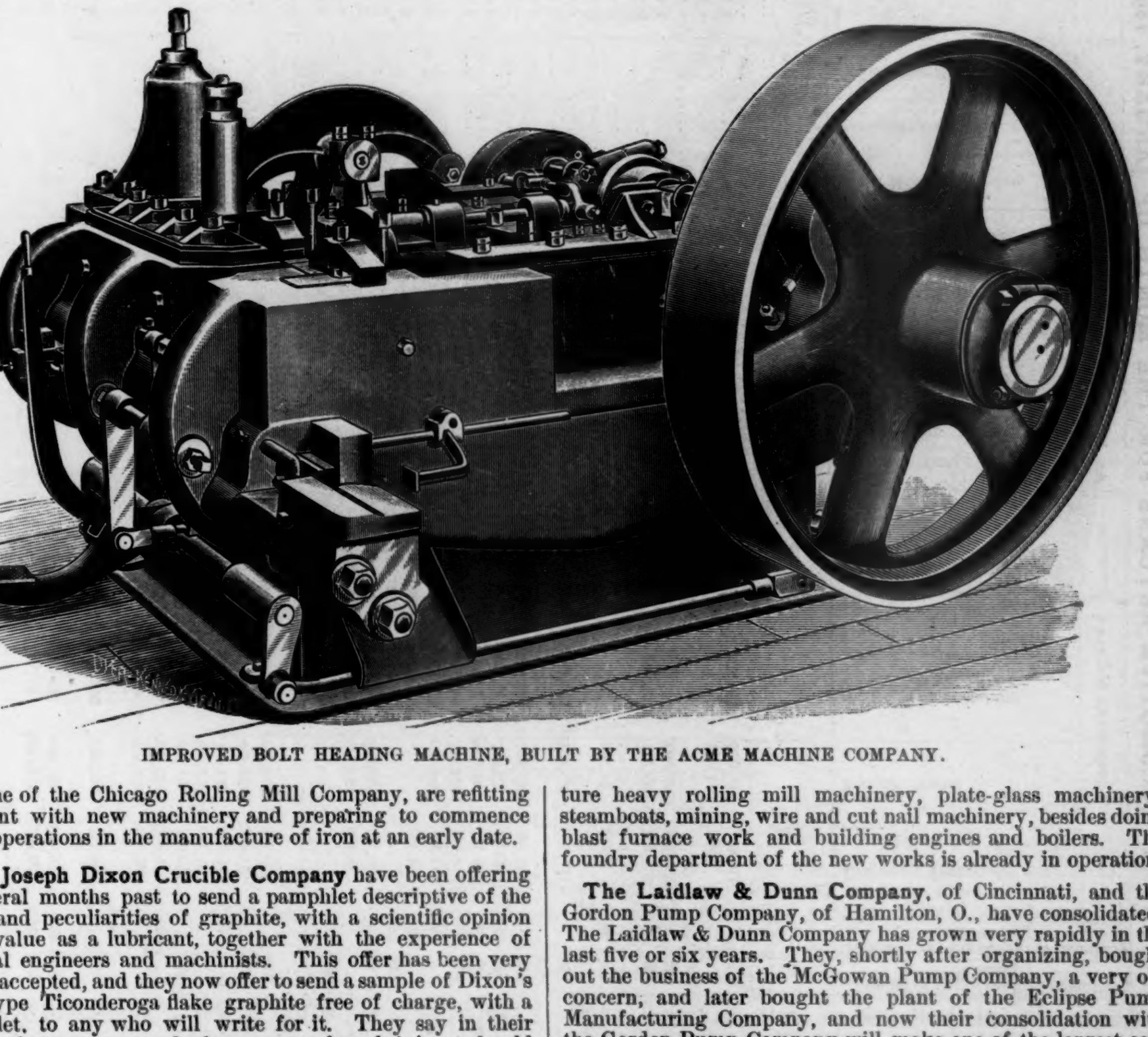
**The Builders' Iron Foundry**, of Providence, R. I., has shipped to Chicago a 36-in. Venturi meter, manufactured under the patents of Clemens Herschel, C.E., New York City. This meter will be placed in the extreme southeast corner of the grounds, and will measure the entire water supply of the Columbian Exposition (about 24,000,000 galls. a day). The recording apparatus will be exhibited in the adjacent building of the sewage cleansing works.

**Westinghouse, Church, Kerr & Company** has been awarded the contract for the new power house of the Newton & Boston Street Railway, at Newtonville, Mass. The steam pressure will be 130 lbs., using Babcock & Wilcox boilers. The generator-room will contain two Westinghouse compound engines, condensing, driving Thomson-Houston multipolar generators. The original installation is for 400-H. P., and the station is to be in operation July 1.

**The Chicago Forge & Bolt Company**, 40th Street and Stewart Avenue, Chicago, have recently leased to Pittsburgh parties the old rolling mill which was operated by the Straight Fiber Iron Company until its destruction by fire some six or seven years ago. The new company, who will operate under the name of the Chicago Rolling Mill Company, are refitting the plant with new machinery and preparing to commence active operations in the manufacture of iron at an early date.

**Westinghouse Machine Company** have been running their works for a year with a full night force. The shops are crowded with a large amount of heavy work in addition to their regular line of manufacture. There are now coming through ten 600-H. P. compound engines, of which eight are for the Philadelphia Traction Company, for direct coupling to multipolar generators, and two are to fill an order placed by E. D. Leavitt for the Calumet and Hecla mines, to be used in driving electric pumps for mine drainage. The company has just completed the shipment of six 1,000-H. P. engines for the Westinghouse Electric Company, to be used in filling its contract for lighting the World's Fair. These engines are also coupled direct to 1,000 light generators. They stand 18 ft. high and make 200 revolutions per minute.

**The General Engineering Company** of Wheeling, W. Va., have recently sold several of the large punching and shearing machines which we illustrate on another page. They are just now making arrangements for their removal to Harvey, Ill., where modern shops have been built which are fully equipped with modern tools, switch facilities, traveling cranes, steam-heating apparatus and electric lights. Their main building is of brick, 360 ft. × 100 ft. The auxiliary shops, such as blacksmith shop, engine and boiler rooms, pattern shop and storage buildings, are also of brick. They will continue to manufacture heavy rolling mill machinery, plate-glass machinery, steamboats, mining, wire and cut nail machinery, besides doing blast furnace work and building engines and boilers. The foundry department of the new works is already in operation.



IMPROVED BOLT HEADING MACHINE, BUILT BY THE ACME MACHINE COMPANY.

**The Joseph Dixon Crucible Company** have been offering for several months past to send a pamphlet descriptive of the nature and peculiarities of graphite, with a scientific opinion of its value as a lubricant, together with the experience of practical engineers and machinists. This offer has been very widely accepted, and they now offer to send a sample of Dixon's pure type Ticonderoga flake graphite free of charge, with a pamphlet, to any who will write for it. They say in their circular that every one who has any use for a lubricant should make themselves thoroughly posted in regard to one which possesses such peculiar properties, and should avail himself of a chance to see a sample and learn of its many uses.

**The Lake Erie Engineering Works** have just completed the machine work on two barbettes for the cruiser *New York*. Each of the plates is made in four parts 10½ in. thick and bent to a radius of 10 ft., making a circle 20 ft. in diameter. The four plates, when so formed into this circle, make a ring 20 ft. in diameter, 6 ft. high and 10½ in. thick, and weigh, in the rough, over 90 tons. This work was done upon a big lathe in their shop which both turned off and bored out the ring, as well as faced the edges.

**The Laidlaw & Dunn Company**, of Cincinnati, and the Gordon Pump Company, of Hamilton, O., have consolidated. The Laidlaw & Dunn Company has grown very rapidly in the last five or six years. They, shortly after organizing, bought out the business of the McGowan Pump Company, a very old concern, and later bought the plant of the Eclipse Pump Manufacturing Company, and now their consolidation with the Gordon Pump Company will make one of the largest concerns in the country. The new company will incorporate under the name of The Laidlaw-Dunn-Gordon Company, with a capital stock of $700,000, $200,000 of which will be preferred stock. None of the stock will be sold to the public, but will all be taken by the present stockholders of the two companies. The Directors of the new company will be Robert Laidlaw, Walter Laidlaw, J. W. Dunn, Thomas McDougall, Thomas T. Gaff, Alexander Gordon, Robert C. McKinney, the first five being of Cincinnati, and the last two of Hamilton, O. The officers of the new concern will be Robert Laidlaw as President, Walter Laidlaw as Vice-President and General Manager, and J. W. Dunn as Secretary and Treasurer. A new factory will soon be built, probably at Cincinnati.

## LOCOMOTIVE RETURNS FOR THE MONTH OF JANUARY, 1893.

| Name of Road. | Number of Serviceable Locomotives on Road. | Number of Locomotives Actually in Service. | Locomotive Mileage. Passenger Trains. | Freight Trains. | Service and Switching. | Total. | Average per Engine. | Av. Train. Passenger Cars. | Freight Cars. | Coal Burned per Mile. Passenger Train Mile. | Freight Train Mile. | Service and Switching Mile. | Train Mile, all Service. | Passenger Car Mile. | Freight Car Mile. | Cost per Locomotive Mile. Repairs. | Fuel. | Oil, Tallow and Waste. | Other Accounts. | Engineers and Firemen. | Wiping, etc. | Total. | Cost per Car Mile. Passenger. | Freight. | Cost of Coal per Ton. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. | Cts. | $ |
| Alabama, Great Southern | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| Alabama & Vicksburg | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| Atchison, Topeka & Santa Fé | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| Canadian Pacific | 611 | .... | 475,216 | 677,672 | 381,476 | 1,534,364 | 2,511 | .... | .... | .... | .... | .... | 80.12 | .... | .... | 4.50 | 13.68 | 0.45 | .... | 5 76 | 1.53 | 25.92 | .... | .... | 3.32 |
| Chic., Burlington & Quincy | .... | .... | 523 | 1,605 | .... | .... | 3,568 | .... | .... | .... | .... | .... | 98.52 | .... | .... | 4.52 | 6.93 | 0.26 | 0.42 | 6.90 | .... | 19.03 | .... | .... | 1.41 |
| Chic., Milwaukee & St. Paul | 820 | .... | .... | .... | .... | 2,710,814 | .... | .... | .... | .... | .... | .... | 80.02 | .... | .... | 4.57 | 8.39 | 0.28 | .... | 6.85 | .... | 20.09 | .... | .... | 2.05 |
| Chic., Rock Island & Pacific | 552 | .... | 559,330 | 965,662 | 431,001 | 1,955,993 | 3,543 | .... | .... | .... | .... | .... | 72.43 | .... | .... | 2.93 | 7.07 | 0.25 | 2.93 | 5.99 | 0.44 | 26.95 | .... | .... | 2.70 |
| Chicago & Northwestern | 888 | .... | 695,922 | 1,438,101 | 701,567 | 2,835,590 | 3,193 | .... | .... | .... | .... | .... | 94.20 | .... | .... | 3.99 | 9.80 | 0.38 | .... | 6.38 | 0.92 | 20.97 | .... | .... | .... |
| Cincinnati Southern | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| Cumberland & Penn* | .... | 24 | 5,319 | 34,577 | .... | 39,896 | 1,662 | .... | .... | .... | .... | .... | 94.24 | .... | .... | 9.06 | 5.12 | 0.39 | .... | .... | 1.87 | 16.44 | .... | .... | .... |
| Delaware, Lackawanna & W. Main L. | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| Morris & Essex Division | 158 | .... | 168,868 | 153,844 | 108,326 | 431,038 | 2,729 | .... | .... | .... | .... | .... | 71.58 | .... | .... | 3.55 | 11.22 | 0.39 | .... | 6.48 | .... | 21.64 | .... | .... | 3.10 |
| Hannibal & St. Joseph | 75 | .... | .... | .... | .... | 262,083 | 3,744 | .... | .... | .... | .... | .... | 97.13 | .... | .... | 8.23 | .... | 0.15 | 0.37 | 6.90 | .... | 23.40 | .... | .... | .... |
| Kansas City, F. S. & Memphis | 148 | .... | 103,988 | 295,571 | 129,749 | 529,308 | 3,577 | .... | .... | .... | .... | .... | 70.94 | .... | .... | 2.98 | 5.75 | 0.28 | 0.43 | 7.38 | .... | 16.82 | .... | .... | 1.57 |
| Kan. City, Mem. & Birm | 41 | 36 | 36,358 | 62,065 | 12,208 | 110,631 | 3,073 | .... | .... | .... | .... | .... | 73.58 | .... | .... | 3.52 | 3.92 | 0.24 | 0.41 | 7.00 | .... | 15.09 | .... | .... | 1.03 |
| Kan. City, St. Jo. & Council Bluffs | 39 | 36 | 60,551 | 40,094 | 42,624 | 143,269 | 3,770 | .... | .... | .... | .... | .... | 72.18 | .... | .... | 4.14 | 6.96 | 0.16 | 0.36 | 5.97 | .... | 17.59 | .... | .... | .... |
| Lake Shore & Mich. Southern | 590 | .... | 448,627 | 924,967 | 530,969 | 1,904,563 | 3,211 | .... | .... | 77.03 | 98.12 | 40.25 | 76.54 | .... | .... | .... | .... | 0.06 | .... | 7.16 | 0.17 | 7.39 | .... | .... | 1.54 |
| Louisville & Nashville | .... | 345 | 435,104 | 804,215 | 409,658 | 1,647,977 | 4,776 | 5.02 | 15.76 | 68.65 | 120.79 | 54.17 | 89.65 | 18.72 | 7.42 | 4.27 | 7.06 | 0.26 | 1.64 | 6.14 | 0.60 | 19.97 | 3.41 | 1.56 | 1.58 |
| Manhattan Elevated | .... | 292 | 774,412 | .... | 60,398 | 834,810 | 2,858 | .... | .... | .... | .... | .... | 51.41 | .... | .... | 2.50 | 10.10 | .... | 0.30 | 9.00 | .... | 21.90 | .... | .... | 3.92 |
| Mexican Central | 146 | 115 | .... | .... | .... | 434,901 | 3,781 | .... | .... | .... | .... | .... | 80.61 | .... | .... | 4.54 | 17.87 | 0.46 | 0.22 | 5.06 | 0.80 | 28.95 | .... | .... | 5.43 |
| Mil., L. S. & Western | 112 | .... | 76,727 | 132,040 | 80,352 | 289,119 | 2,581 | .... | .... | .... | .... | .... | 87.95 | .... | .... | 2.91 | 12.50 | 0.23 | .... | 6.36 | 0.94 | 22.94 | .... | .... | 2.80 |
| Minn., St. Paul & Sault Ste. Marie | .... | .... | 62,129 | 194,148 | 35,747 | 292,024 | .... | 4.40 | 14.47 | .... | .... | .... | 101.21 | .... | .... | 5.33 | 16.59 | 0.28 | .... | 7.09 | .... | 29.29 | .... | .... | 3.27 |
| Missouri Pacific | 339 | 301 | .... | .... | .... | 1,139,269 | 3,785 | 4.42 | 15.81 | 70.72 | 130.04 | .... | 98.13 | .... | .... | 6.45 | 7.47 | 0.34 | 1.32 | 6.62 | 1.56 | 23.76 | 4.54 | 1.86 | 1.50 |
| Mobile & Ohio | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| N. O. and Northeastern | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| N. Y., Lake Erie & Western | 610 | .... | 459,896 | 944,458 | 285,920 | 1,690,274 | 2,770 | 4.40 | 19.40 | 95.80 | 142.10 | 182.40 | .... | .... | .... | 4.37 | 8.47 | 0.39 | 2.80 | 7.48 | 1.20 | 24.71 | .... | .... | .... |
| N. Y., Pennsylvania & Ohio | 259 | .... | 134,422 | 432,343 | 144,772 | 711,537 | 2,747 | 5.30 | 16.10 | .... | .... | .... | .... | .... | .... | 4.67 | 6.65 | 0.32 | 2.36 | 6.93 | 1.13 | 23.06 | .... | .... | .... |
| Norfolk & Western, Gen. East. Div.† | .... | .... | 115,649 | 237,500 | 54,884 | 408,033 | 2,534 | 4.60 | 19.20 | 53.10 | 133.40 | .... | .... | 11.50 | 6.90 | 5.90 | 3.80 | 0.70 | .... | .... | .... | 10.40 | 11.50 | 6.90 | .... |
| General Western Division† | .... | .... | 105,342 | 253,488 | 43,417 | 402,247 | 2,623 | 5.47 | 14.21 | 90.00 | 141.00 | .... | 150.65 | 16.56 | 9.99 | 11.09 | 4.64 | 0.72 | .... | .... | .... | 16.45 | .... | .... | .... |
| Ohio and Mississippi | 121 | .... | 146,040 | 197,086 | 92,354 | 435,480 | 3,599 | .... | .... | .... | .... | .... | 93.72 | .... | .... | 2.92 | 4.53 | 0.22 | 0.35 | 5.40 | 1.44 | 14.86 | .... | .... | ..82 |
| Old Colony | .... | 228 | 335,700 | 135,437 | 127,704 | 598,841 | 2,635 | .... | .... | .... | .... | .... | 66.77 | .... | .... | 3.47 | 12.52 | 0.62 | .... | 6.79 | 0.80 | 24.20 | .... | .... | 3.75 |
| Philadelphia & Reading | .... | .... | 467,834 | 355,223 | 1,024,981 | 1,848,038 | .... | .... | .... | .... | .... | .... | 78.89 | .... | .... | 4.82 | 7.81 | 0.30 | .... | 5.99 | 0.39 | 19.31 | .... | .... | .... |
| Southern Pacific, Pacific System | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| Union Pacific | 991 | .... | 714,275 | 1,868,961 | 513,795 | 2,597,031 | 2,620 | 5.46 | 16.36 | .... | .... | .... | 101.21 | .... | .... | 7.01 | 9.55 | 0.43 | 1.00 | 8.06 | 1.17 | 27.22 | 4.68 | 2.10 | 1.88 |
| Vicksburg, S. & P. | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| Wabash | 426 | 361 | 416,091 | 751,604 | 290,035 | 1,457,730 | 4,038 | .... | .... | .... | .... | .... | 90.90 | .... | .... | 3.77 | 5.21 | 0.32 | .... | 6.35 | 0.85 | 16.50 | 2.90 | 1.30 | 1.10 |
| Wisconsin Central | 149 | 116 | 123,557 | 212,039 | 57,934 | 393,530 | 2,641 | .... | .... | .... | .... | .... | 94.29 | .... | .... | 4.48 | 11.47 | 0.28 | .... | 7.25 | .... | 28.48 | .... | .... | 2.45 |

NOTE.—In giving average mileage, coal burned per mile and cost per mile for freight cars, all calculations are made on the basis of *loaded* cars.

* Switching engines allowed 6 miles per hour; wood, construction and gravel trains, 10 miles per hour.

† Wages of engineers and firemen not included in cost.

**Riehle Brothers' Testing Machine Company**, Philadelphia, report the following very recent orders: American Telephone & Telegraph Company, New York, one 30,000-lb. vertical screw power testing machine; Syracuse Water Board, Syracuse, N. Y., one Riehle United States Standard 1,000-lb. cement testing machine, complete, with molds, sieves, mixing table and special appliances; Metropolitan West Side Elevated Railroad Company, Chicago, Ill., one 1,000-lb. United States Standard cement testing machine, with worm gear, rubber-pointed grips, and many sundry appliances; Leland Stanford, Jr., University, Palo Alto, Cal., one 20,000-lb. vertical screw power testing machine, with indicator; Chicago, St. Paul, Minneapolis & Omaha Railroad Company, St. Paul, Minn., one 150,000 lb. screw power testing machine, with Vernier poise, beam and tools for tensile, compression and transverse strains; Maine State College, Orono, Me., one 60,000-lb. vertical screw power testing machine, complete; University of California, Berkeley, Cal., one 5,000-lb. transverse testing machine with indicator for elastic limit; Madison Car Company, Indianapolis, Ind., one 20,000-lb. horizontal screw power testing machine; L. Hilgartner & Son, Baltimore, Md., one marble basin hole cutter; A. Plamondon Manufacturing Company, Chicago, Ill., one 3,000 lb. transverse testing machine with indicator; Gillett-Hertzog Manufacturing Company, Minneapolis, Minn., one 5,000-lb. transverse testing machine, with indicator for testing specimens 48 in. long, and other smaller orders.

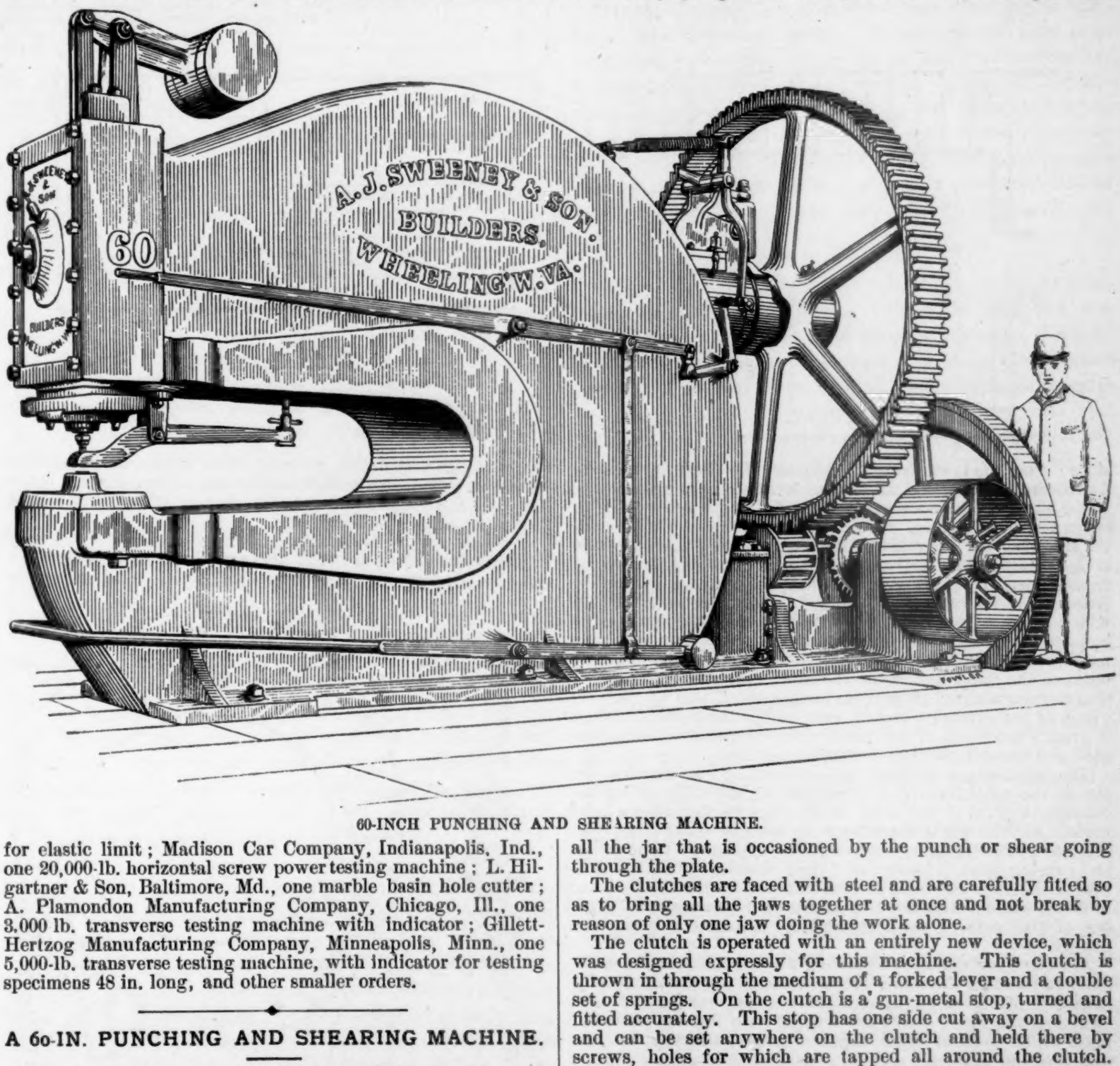
## A 60-IN. PUNCHING AND SHEARING MACHINE.

We give a perspective view of a heavy 60-in. punching and shearing machine that is made by the General Engineering Company, successors to A. J. Sweeney & Company, of Harvey, Ill. The machine has a depth of throat of 61 in., and is built to punch a 6-in. hole through ¾-in. steel plate, and on an actual test punched a 6-in. hole through 1¼ in. steel. The stripper in the throat is adjustable so as to strip thick or thin plates as soon as the holes are punched, without lifting the plate too far off the die, thus obviating the danger of injuring it in falling.

The sliding head is operated by means of a cast steel cam pintle, with large wearing surfaces, and the cam pintle is so constructed as to give little or no wear. The sliding head is carefully scraped to a true bearing, and has a gun-metal gib to adjust what little wear there is to head through long service.

The cam-shaft is of hammered steel, 9 in. in diameter, with large bearings all bushed with very hard gun-metal, and the cam is 1½ in. eccentric to the center of the shaft, giving the punch a 3-in. stroke. The machine is fitted with splitting shears 30 in. long, and tie bolts 3 in. in diameter are provided for the throat when the machine is used for shearing plates of very heavy thickness.

The pulleys are 30 in. diameter by 6¼ in. face, and run at a speed of 192 revolutions per minute, giving 24 strokes per minute to the machine. The gear is 8 ft. 6 in. in diameter, and is geared to a shrouded pinion 8 to 1. The fly-wheel is 66 in. diameter and has 6¼ in. × 6¼ in. rim and elliptical shaped arms, and weighs 2,500 lbs. The pulleys are geared at right angles to pinion shaft to allow the machine to be driven direct from the line shaft. The sliding head is counterbalanced and has a heavy spring in the head connected to the stirrup to take all the jar that is occasioned by the punch or shear going through the plate.




60-INCH PUNCHING AND SHEARING MACHINE.

The clutches are faced with steel and are carefully fitted so as to bring all the jaws together at once and not break by reason of only one jaw doing the work alone.

The clutch is operated with an entirely new device, which was designed expressly for this machine. This clutch is thrown in through the medium of a forked lever and a double set of springs. On the clutch is a gun-metal stop, turned and fitted accurately. This stop has one side cut away on a bevel and can be set anywhere on the clutch and held there by screws, holes for which are tapped all around the clutch. When the clutch is released by lifting the stop-pin, it makes one revolution, and the beveled side of the stop strikes the stop-pin and forces the clutch out of mesh.

The machine can be operated and started from either side by hand or foot, and the levers connect with the stop-pin and require but very slight pressure to start the machine. By this means the clutch can be set to stop at any point of the stroke, giving great advantage in being able to always have the punch stop close to the work, whether punching thin sheets or thick sheets.

The above arrangement makes a positive and perfect interlocking clutch, making an accident to the operator impossible while adjusting the punches, dies, and shears.

The weight of the machine is 56,000 lbs.

## LOCOMOTIVE BOILER IMPROVEMENT.

J. T. Connelly, of Milton, Pa., has brought out some improvements in the construction of a locomotive boiler, which we illustrate herewith. It is intended to obviate the collection of mud or other deposits on the top of the fire-box, and of securing at the same time a greater area of heating surfaces, so that the maximum quantity of steam may be generated and the pressure maintained, while the strength and durability of the boiler is, at the same time, materially increased. In our engraving fig. 1 is a vertical longitudinal section of the boiler. Fig. 2 is a transverse section along the line *Y Y*.

Referring to the drawings, *B* designates the smoke-box, *C* the barrel, *D* the fire-box chamber, *E* the combustion chamber, and *F* the fire-box, which is preferably formed of a single sheet, and is in cross-section segmentally curved at its top and sides; from the lower edge of the latter the sheet is extended downward and parallel as shown, forming a grate space and water legs. At its forward end the fire-box is provided with an extension projecting within the barrel for about one-half the space usually occupied by the boiler flues. The extension is also formed of a single sheet, and is in cross-section circular from its rear end to about its longitudinal center, and from the latter point its contour is changed to its extreme front end, which is approximately oval. The bottom of the extension is inclined from its front end downward to its rear end, thus tending to prevent the accumulation of mud or other deposits between the inner and outer shells, and also the collection of coal or dust within. It will be further noted that by the provision of the extension and its novel shape the heating surface is greatly increased at the point where steam must be generated and maintained to give efficient service.

The advantages claimed for this form of construction are that in the usual form of construction of locomotive boilers the extreme length of the flues cause them to sag after a brief period, and the slight space between them becomes filled with mud or other deposits, impairing the efficiency of the boiler and causing what is known as "mud burning." This condition of the flues and form of construction, where the flues are in direct contact with the fire, causes as a consequence burning of the ends of the flues, and the resultant expense and danger.

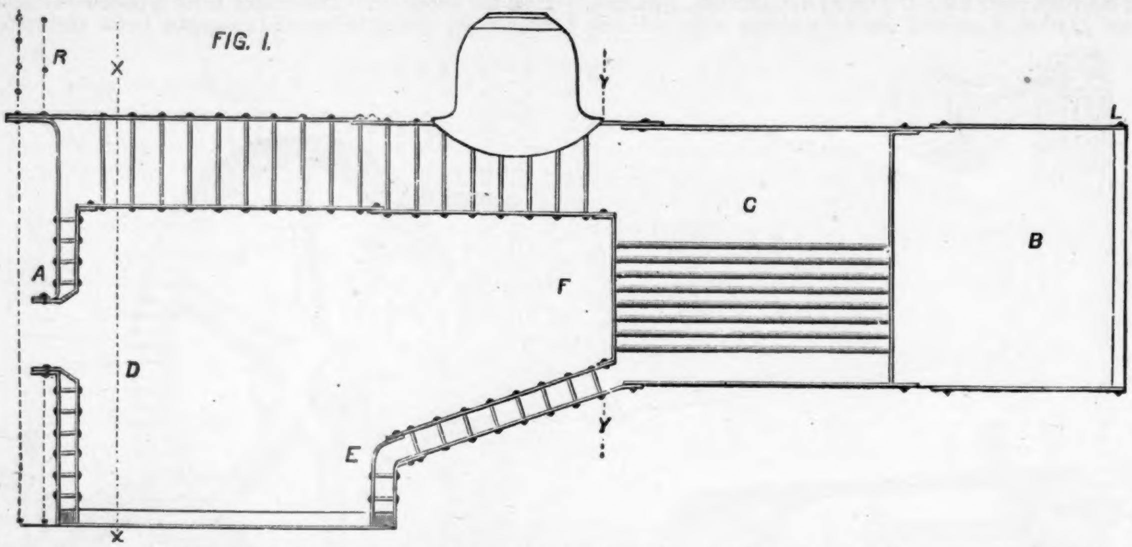
Another disadvantage of the long flues is the material difficulty in cleaning the same. It may also be noted that usually in boilers of this class, by reason of the general form of construction, the inner sheets are formed with flat top surfaces, upon which mud or other deposits collect, affecting the efficiency of the boiler.

To obviate these and other objections is the purpose of this improved boiler. In its form of construction, by reason of the provision of the fire-box extension, the flues are removed from the fire and the danger of burning of the ends claimed to be obviated. By the employment of the extension the flues are shortened and rendered more rigid, thus obviating the liability to sag, and the consequent evil results. It will also be apparent that by constructing the parts of the boiler subject to the greatest pressure approximately cylindrical, and having no weak flange or sharp corners, greater strength is insured, and being without flat surfaces except the legs, back-head and throats, the accumulation of mud or other deposits is lessened or obviated.

The back-head is put in with the flange and double riveted, as shown; this is done on account of the advantages derived from the additional strength and facility of construction.

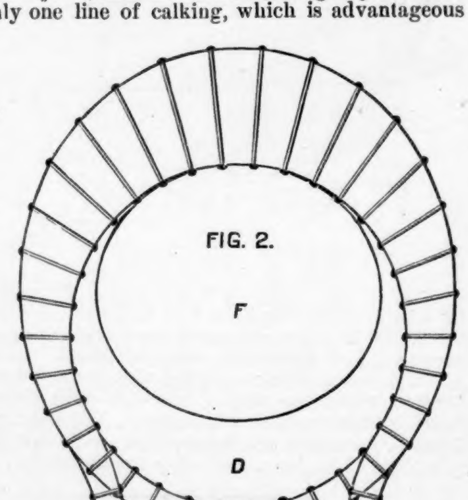
Mr. Connelly has also designed a superior lap joint, shown by fig. 3.

Heretofore in the construction of lap joints for steam boilers there have been objectionable features, which this improvement is designed to overcome, and that is that the lapped ends of the sheets not having any provision for reinforcement, places them without the line of strain when steam pressure is upon it from the inside of the boiler. This strain, which was substantially in a straight line, was found to bend the lap so as not to present a direct line of pull on the rivet, but to bend and force the rivet to assume an axial line obliquely disposed to the line of strain, which not only tended to weaken the boiler at that point, but also to uncalk the seams. The purpose of this improvement is to overcome these and other objections by providing the interior of the boiler with an inside welt, extending laterally to one side, to a width sufficient to place it immediately below the calk line, whereby it relieves the lap joint of any torsion when the calking is being done.




Another feature is to reduce the number of rivets necessary to forming such a joint, and also enabling a tight joint to be made with only one line of calking, which is advantageous

Fig. 3.




from the fact that the expense generally attending the seaming and calking is greatly reduced. These results are attained by the construction and arrangement illustrated in the drawings.

*A* represents a segment of a circular boiler having its ends overlapping each other, and secured to the interior is an inside welt placed so that the calking edge will be about its central longitudinal line, whereby when the sheets are subjected to the impacting process of calking the strain is taken up or absorbed by the welt.